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VOLUME 111, NUMBER 2890

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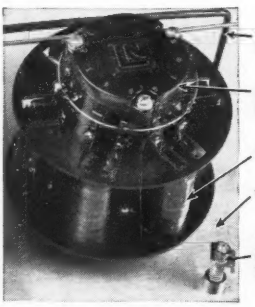

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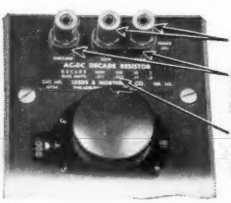

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SCIENCE

Vol. 111 No. 2890 Friday, May 19, 1950

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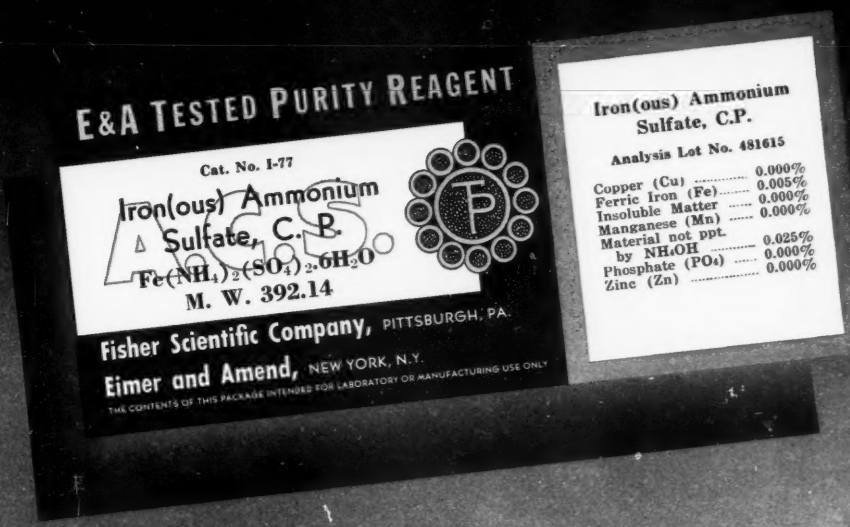

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Heredity, Environment, and Politics[1]

T. M. Sonneborn

Department of Zoology, Indiana University, Bloomington

LESS THAN TWENTY-FIVE YEARS AGO, there was thought to be no way by which environmental conditions could bring about hereditary changes in organisms. Since that time, more and more environmental agents capable of inducing hereditary changes have been discovered: first, temperature and x-rays; then, other ionizing radiations and ultraviolet light; more recently, chemicals such as colchicine, mustard gas, and formalin. These agents alter the chromosomes in both body cells and germ cells, but only the effects produced on the germ cells, or cells from which they are derived, are inherited in sexual reproduction.

About forty years ago, the only well-established types of inheritance were Mendelian and sex-linked, both of which proved to have their bases in the chromosomes. Since that time, there has gradually accumulated a number of examples of non-Mendelian inheritance: first, plastid inheritance; then, plasmon inheritance and Dauermodifikationen; more recently, a type of inheritance determined by cytoplasmic particles known as plasmagenes, with properties like those of nuclear genes and viruses.

Modern genetics has thus gone a long way from its earlier state of knowledge, but it still is a vigorous, young science and is growing rapidly. The question we consider here is whether it is now undergoing a profound metamorphosis into a form with no more readily recognizable relation to its earlier stage of existence than a moth has to a caterpillar. The Chromosome Theory of Heredity and the Theory of the Gene have been declared no longer valid. The growing list of environmental agents that can alter heredity has been declared but a small and relatively insignificant fraction of the genetically active environmental agents. The central feature of the new genetics is held to be the demonstration that acquired characters are not only inherited, but that this is the usual thing.

Establishment of these principles would indeed constitute a profound metamorphosis of genetics; but most professional geneticists refuse to admit their validity. The inheritance of acquired characters is viewed by many of them as an outmoded superstition. Whether right or wrong, this attitude is at least understandable in view of the record. Of the many previous attempts to demonstrate experimentally the inheritance of acquired characters, all have failed. In most cases, the attempts yielded negative results. When positive results were claimed, the work later proved to be fraudulent, indecisive, or incompetently performed; repetition with unobjectionable methods always failed to establish the claims. No wonder most geneticists consider the matter closed.

It takes unusual circumstances to arouse lively interest among geneticists concerning a theory that seems so fully discredited. Unusual circumstances indeed are associated with the newest champion of the inheritance of acquired characters, Trofim Denisovich Lysenko, who has come increasingly into public attention since 1932. These circumstances make the currently debated issues of great importance to every biologist and indeed to every citizen of the world. Lysenko's views have been accepted both by a great nation noted for its interest in and support of science, and by a highly organized, vocal, active, but nonscientific group, distributed throughout the world; moreover, this nation and this group consider the matter of sufficient importance to root out and remove the opposition. This fact places the subject of the inheritance of acquired characters in an entirely new position; it cannot, in this case, be considered as merely a biological controversy. But we must not confuse the issues. For purposes of analysis and understanding, the biological and the political aspects of the matter must be separately and objectively considered. This I shall attempt to do.

Some explanation of my intention to consider the biological aspect of Lysenkoism is perhaps due those of my colleagues who, after careful consideration, maintain that the controversy is not a scientific one at all. That there is a strong political and philosophical element in the controversy cannot be denied, as I shall later show. Nevertheless, I believe many biologists and others hold that the political support given to a biological theory and its agreement with a particular philosophy may be irrelevant with respect to its scientific validity. They have, it seems to me, the right to demand objective, critical consideration of the claims of the new genetics, so that they themselves can decide the extent to which the controversy is or is not scientific. Although both are important, the judgments we reach on the biological claims should be entirely independent of our judgments on the nonscientific aspects of the controversy.

[1] Address of the retiring president of the American Society of Naturalists, presented at the New York meeting, December 30, 1949. Contribution No. 424 from the Department of Zoology, Indiana University.

As the latter have been dealt with extensively by others and are doubtless familiar to all of you, I shall merely touch upon them briefly towards the end of this paper, and shall devote nearly all of my time to a discussion of the biological questions that have been raised.

In reporting and evaluating the work of the Lysenkoists, the language barrier is a source of difficulty. Fortunately, there are three excellent sources of information in English. First is Lysenko's (*9*) treatise of 1943 *Heredity and Its Variability,* translated into English by Dobzhansky. Second, the booklet *The New Genetics in the Soviet Union* by Hudson and Richens (*6*), published in 1946, gives a critical review of about 200 Lysenkoist publications. Third, *The Situation in Biological Science* (*21*), a book published in 1949, contains 58 Russian papers translated into English. Two of these papers are by Lysenko and are his latest statements available in English. They form the basis of my account of his current views.

Lysenkoism: Observations and Interpretations

To be clear and critical, an account of the work and views of the Lysenkoists must make a clean separation between observations and interpretations. Lysenko's statement of his case for the inheritance of acquired characters involves three main classes of observations, each centering about a different method. However, the papers of Lysenkoists also contain other observations of interest in relation to physiological problems. These observations should not be ignored or rejected, even if one should object to the work of the Lysenkoists on the inheritance of acquired characters. They will not be discussed here, however, because in my opinion they do not bear on the genetic question under discussion. The following account will be limited to the observations reported when the three principal methods just mentioned were employed.

The first method is simply to cross different breeds; to rear the hybrids and later generations under conditions best adapted to the type of organism one wishes to obtain; and in each generation, to select for further breeding those individuals that thrive best under these conditions and that most closely manifest the desired characteristics. An important part of the method is to select for the crosses breeds that, by their traits and their range of variation, show promise of yielding after hybridization organisms of the type desired. Using this method of sexual crossbreeding and selection, the Lysenkoists claim to have obtained new breeds of organisms of the sort they set out to obtain.

The second method consists of grafting together two different breeds of plants, especially when the two plants differ in age, one being young and the other mature. According to the Lysenkoists, seeds obtained from *one* component of the graft combination (especially the young component) yield plants with mixed characteristics, some resembling characteristics of one component of the graft combination and some resembling those of the other component in the graft combination. Again, these seeds (and later generations) are grown under specially suitable conditions and deliberate selection is exercised in the choice of plants to yield seed for later generations. This grafting method is reported to have yielded results with a number of plants, especially with tomatoes.

Both of these methods were earlier used by Michurin. They play so important a part in Lysenkoism that this work is usually referred to as Michurinism.

The third method is to expose plants to altered environmental conditions at a certain stage of life and to repeat this for two to four successive generations, selecting for treatment in each generation plants derived from parents most nearly conforming to the type one wishes to obtain. With this method, it is claimed that the desired types were obtained and that they reproduced true to type without further treatment in later generations. The chief observations have been made on cereals, especially wheat and rye, but other plants have also been employed.

We may now turn to the interpretations as a separate and distinct matter. Lysenkoists maintain that the results obtained with all three of the methods are due to the inheritance of acquired characters. When the traits of a plant are modified by subjection to a particular environmental treatment and, after several generations of treatment plants show the new traits without requiring the environmental treatment, it is concluded that the effects of the treatment have become hereditary. When the right environmental conditions are applied at the correct stage of the plant's life, its normal heredity is held to be destabilized and rendered readily alterable by environment.

With respect to the results of grafting, it is held that the two components of the graft form a single unitary organism in which the parts united by grafting interact to destabilize the heredity of each under the influence of the heredity of the other. This assumed interaction is believed to form a hybrid, a graft or vegetative hybrid, entirely comparable to the hybrids formed by the union of gametes in sexual reproduction. The formation of seeds on one part of the graft combination, which develop into plants showing some characteristics of the other part of the

graft combination, is interpreted as inheritance of characteristics acquired from a graft partner. There is another essential feature of the interpretation: the assumed mixed inheritance of the seeds is held to be unstable and environmental conditions are again presumed to determine which hereditary traits become stabilized.

The results obtained by the ordinary method of sexual crossbreeding and selection are interpreted in a similar way. The union of two sexual cells from two different breeds brings together two diverse heredities. This, as in the case of the assumed graft hybrids, is believed to destabilize heredity so that the environmental conditions can bring about and stabilize new hereditary constitutions.

Because they believe these experiments demonstrate the inheritance of acquired characters, the Lysenkoists conclude that heredity cannot be based on any isolated special substance. All parts of the plant and all parts of each cell—even the sap—are believed to be materials of heredity which form an intimately interacting genetic system. As this conclusion is inconsistent both with the isolation of the germ plasm and with the chromosomes as the sole material basis of heredity, they conclude further that these views are false. Believing them to be essential features of neo-Mendelism, they discard the whole of neo-Mendelian genetics.

A Revolution in Genetics?

The interpretations of the Lysenkoists, taken as a whole, are thus in fundamental disagreement with what has been regarded as valid generalization from countless observations. To judge the scientific legitimacy of so complete a revolution, we must seek answers to three questions: (1) Are the experiments decisive for the proposed interpretations? (2) Do these interpretations account for observations that cannot be accounted for by the previous well-tested generalizations? (3) Do these interpretations provide a simpler or more reasonable explanation for all or most of the available observations?

Neo-Mendelism

It may be said at once that the Lysenkoist interpretations do not and cannot account for the facts of neo-Mendelism, particularly the quantitative facts. The Mendelian ratios in inheritance, confirmed countless times for a great variety of hereditary traits in microorganisms, plants, animals and man, by investigators in all countries of the world in which biological science is cultivated, including Russia—and even by beginning students in biology—find no place in the new genetics. Lysenkoists do not admit the cogency of the numerical facts of observation that form the starting point and basis of Mendelian genetics. Their opposition is based on four points.

First, they claim that the Mendelian ratios are due, not to the segregation and recombination of genes, but to the action of environment upon hybrids whose heredity is destabilized by the very fact of being hybrid. In support of this claim, they report that the ratios vary with the environmental conditions. In this connection, two facts should be noticed. Disturbances of Mendelian ratios due to differences in viability of the segregating classes are well known to geneticists, and environmental conditions are known to affect the proportion that survives; but the influence of environment on *survival* of a class does not justify concluding that environment determines the *production* of that class. More important, the interpretation that environment determines the production of the segregating classes completely fails to account for the common observation of definite segregation ratios such as 3:1.

Second, the Lysenkoists maintain that some hereditary traits fail to show the 3:1 ratio. Examples from Michurin's work on fruit trees and from the work of others are cited as evidence. This fact is not disputed by Mendelian geneticists. Indeed they can provide many more examples, as the textbooks of genetics show. The difference appears in the way this fact is handled. The Lysenkoists seem to argue that if one can find cases in which the 3:1 ratio does *not* occur, then the innumerable cases in which it *does* occur can be of no significance. The Mendelians on the other hand have used these other ratios as critical tests of their chromosome and gene theories. They reasoned that if these theories are correct, each ratio should be correlated with predictable and observable features of chromosome behavior. Their amazing success in demonstrating such correlations in the study of sex-linked inheritance, nondisjunction, linkage and crossing over, polyploidy, heteroploidy, inversions, translocations, deficiencies, and duplications leaves no possibility of legitimate doubt as to the direct relation between the ratios observed in breeding experiments and the behavior of the chromosomes observed through the microscope.

The third objection made by the Lysenkoists is their claim that attempts to repeat the basic experiments, such as Mendel's pea crosses, did not yield the 3:1 ratio. The data purporting to show this (according to Hudson and Richens, *6*) were analyzed by Kolmogorov and shown not to differ significantly from the 3:1 ratio; he considered the data to be, on the contrary, a confirmation of Mendel.

This brings us to the fourth objection, which is a most important one. Lysenko holds that statistics should have no place in biology because it represents

incertitude. By rejecting statistics, Lysenko rejects statistical analysis of the significance of results, including the repetition of Mendel's crosses, and at the same time rejects all statistical aspects of genetics. Let us be entirely clear on this. The Lysenkoists are not maintaining that statistics has been badly applied; they claim it is *inapplicable* to biology and that *any attempt* to apply it is *unscientific*. As scientists, you will not wish or need me to justify the use of statistics in biology or to draw the obvious conclusions.

It is important, however, to realize that Lysenko's rejection of neo-Mendelism is not merely rejection of an interpretation. He denies some of the basic facts of observation (e.g., the 3:1 ratio); he ignores other basic facts of observation (the large number of correlations between chromosome behavior and the ratios obtained in breeding experiments); and he rejects as unscientific the methods of statistics used by biologists the world over.

It must therefore be concluded that justification of the revolution in genetics proposed by the Lysenkoists cannot be based on its providing a more reasonable explanation than the current one for the previously available observations. It provides no explanation whatever for the quantitative results or for the observed relation between chromosome behavior and breeding results. This alone is sufficient ground for concluding that the Lysenkoists have no new genetics that can take the place of the genetics current elsewhere.

The Inheritance of Acquired Characters

Yet, the contribution of the Lysenkoists could still be a considerable one, even if less than they claim, provided they presented decisive evidence for phenomena previously undemonstrated, particularly if these phenomena could not be accounted for by the previous corpus of genetic generalizations. For example, if their observations on environmental action, on grafts, and on sexual hybrids justified their interpretation of the inheritance of acquired characters, this would indeed be a great contribution. We must therefore examine the evidences in relation to that interpretation.

Let us consider first the most direct evidence, the evidence that purports to have demonstrated the inheritance of acquired characters by exposing plants to the action of effective environmental conditions during a sensitive phase of their life history. The claims as to inherited effects of vernalization may be taken as the typical and main example.

Winter wheat ordinarily must spend the winter in the field, not maturing until the following fall; but if the seeds are moistened and the seeds or seedlings are exposed for a period to low temperature, seeds planted in the spring will yield mature plants in the same year. This treatment is known as vernalization. Some breeds of wheat—spring wheats—mature in the same year without vernalization. Lysenko claims that, after a few generations in which the vernalization treatment was applied to winter wheat, he ended up with wheats that did not require the vernalization treatment. He maintains this evidence demonstrates that the effects of the vernalization treatment have become inherited, winter wheat being transformed into spring wheat.

According to Lysenko, success depends upon exploiting what he calls "phasic development." He holds that organisms develop in a sequence of phases or stages, each of which requires certain conditions. The mode of development in later stages depends on how development proceeds at each earlier stage. By subjecting the organism at a certain stage to unusual conditions, this stage will develop in an unusual way and, consequently, later stages will also be modified. Up to this point in his argument, there is little ground for disagreement. When he goes beyond this, however, and claims that the induced alteration in development is inherited by later generations, his claims are in direct opposition to the experience of others.

A close parallel to Lysenko's method is to be found in work of a sort initiated long ago by Richard Goldschmidt on animals. He also found that the development of an organism could be altered by applying appropriate environmental conditions to a definite stage of development. Moreover, the effects produced were apparently copies of the effects of known gene mutations. He therefore called these effects "phenocopies." But Goldschmidt and his followers report that phenocopies are limited to the individuals directly exposed to the unusual environment; the next generation develops as if it had never been exposed to those conditions. Thus, the method employed by Lysenkoists does not give similar results in the hands of other workers. What is the explanation of the discrepancy?

The answer to this question is suggested by the published accounts of the experiments performed by the Lysenkoists. As Hudson and Richens pointed out, serious possible sources of error in the experiments were not controlled. First, the Lysenkoists made no claim to have used sterile soils. Hence, *one seed* of spring wheat in a plot sown with winter wheat could yield some of the results reported. In Lysenko's first claim of success, *a single seed* from the entire plot came through the initial treatment and gave rise to all the later generations of spring wheat! In some of the later work, however, success has been reported for high proportions of the treated plants.

Secondly, the accounts of the experiments make no mention of controls, of parallel plots planted with untreated seeds. It is therefore not clear that the initial batch of seeds was uniformly of one kind; the possibility remains that the seeds sown included some seeds of spring wheat. Third, in the absence of adequate controls, it is not clear that the seeds were genetically pure. If they had from the start been hybrid for the traits which were to be selected, the subsequent selection of the desired types would conform strictly to previous knowledge of Mendelian segregation. Still other possibilities of error have been pointed out; but those that have been mentioned are enough to make clear that nothing whatever can be legitimately concluded from the published accounts except that the experimenters should repeat the experiments with adequate controls.

Let us now turn to the work with the grafting method. In apparent support of the claims of the Lysenkoists are examples in which an effect is known to be transmitted from one to the other part of a graft combination. Is then the difference between the claims of the Lysenkoists and others the relatively trivial one of whether a phenomenon is rare or common?

No, the difference is a fundamental one. Certain traits—so far as now known, nearly all—are held by the Mendelians to be determined by chromosomal genes. These genes and chromosomes do not wander about from cell to cell. Hence, according to the Mendelians, a graft pure for one such trait (e.g., yellow fruit) and a stock pure for an alternative trait (e.g., red fruit) could not produce a seed that is hybrid for these traits except by union of a pollen nucleus of one kind with an egg cell of the other kind. However, the Mendelians agree that certain genetic particles—call them viruses or plasmagenes as you wish—can migrate between stock and graft, but very few traits are known to be determined by such migratory particles.

On the other hand, the Lysenkoists—denying the validity of the gene theory—maintain that the sap carries the physical basis of the *entire* heredity of the plant. As the sap is free to move between stock and graft, they claim that the material basis of the *full* heredity of each may readily be carried into the other.

Thus both the Mendelians and the Lysenkoists agree that the material basis of certain exceptional traits could pass between stock and graft, but they differ fundamentally with respect to this possibility for the usual kind of trait. The critical test therefore is to follow traits of the common sort, which the Mendelians claim to be determined by chromosomal genes. With reference to such decisive traits, the experience of the Lysenkoists is in fundamental opposition to the experience of Mendelians.

The experience of the Lysenkoists may be summarized by two quotations from Lysenko himself. "*Any* character may be transmitted from one breed to another by means of grafting *just as well* as by the sexual method" (*21*, p. 39). Further, "*every* graft of a phasically young plant produces changes in heredity" (*21*, p. 608). Among the Mendelians, perhaps no one has had more experience in this field than M. B. Crane, of the John Innes Horticultural Institute. He summarized his experience recently as follows (*2*):

> I have been profoundly interested in the growing, breeding and grafting of plants and trees for nearly fifty years, and have raised thousands of fruit trees from seed; grown many both on their own roots and (as grafts) on the roots of others. I have also grafted twigs of an old variety on a young seedling on its own roots and also twigs of young seedlings onto old varieties. . . . In all these [which he enumerated in detail] there has not been the slightest indication of the different roots [i.e., stocks] having had *any* influence on the seedlings [i.e., grafts]. That is to say in my experience no vegetative hybridization occurred.

Thus, what is reported by Lysenkoists as the common and usual result is not found at all in the experience of Crane in the course of nearly fifty years of intensive investigation. And Crane's results are typical of those of the Mendelians, although some contradictory observations have been recorded. Again, therefore, we are faced with differences in the facts of observation that cannot be lightly put aside. To what is the discrepancy due? Hudson and Richens give a careful analysis of the work prior to 1946. They point out in it a number of serious experimental deficiencies, of which I will cite only two. First, in much of the work controls were not reported. Obviously, it is essential that the plants used in grafting be tested to demonstrate that they were not already, before the grafts were made, hybrid for the characters under investigation. According to the reports of those who have seen Lysenko's plants and his experimental plots, the plants employed were genetically highly mixed, so that this could be a serious source of error. Second, in much of the work no mention is made of bagging the flowers to prevent fertilization by pollen from the other part of the graft combination and from other plants. It is absolutely essential that this possibility also be controlled, for it involves another mechanism known to be capable of yielding the observed results. Until these and other sources of error are shown by adequate evidence to have been avoided, the Lysenkoist interpretation remains unjustified.

There is a more general criticism raised by Hudson and Richens against the validity of the interpretations of work by both of the methods we have discussed. You will recall that the Lysenkoists claim to obtain success with both of these methods only when the proper environmental conditions are employed. Their own failures and the failures of others to confirm their results are attributed to failure to use the proper conditions. Yet the proper conditions remain unspecified and, presumably, unspecifiable. So long as all failures are attributed to unknown causes, the hypothesis becomes elastic, essentially incapable of critical testing, and therefore useless.

We are now left with only the results of their first method, the ordinary sexual hybridization of different breeds followed by selection for a desired type under favorable environmental conditions. Lysenko maintains that heredity is so destablilized by mixing two heredities that environment can then readily impress upon the progeny of the hybrids the desired traits. For the interpretation that the traits selected are due to the action of the environment *not one bit of evidence is presented.* Moreover, it will be apparent to everyone with the least acquaintance with genetics that the *observations* reported are precisely what happens according to neo-Mendelism. Among the progeny of a hybrid, the factors or genes recombine in all possible ways and provide a variable group of individuals from which one can readily select diverse types. If the organisms that are hybridized are themselves genetically impure, or hybrid, still greater variability arises and selection can accomplish even more. The Lysenkoist interpretation of the results obtained with this method is thus entirely gratuitous. The results are expected on classical theory and no evidence or cogent reason is given to justify substituting a different explanation.

The materials on which to base answers to the three questions raised earlier are now before us. (1) The experiments of the Lysenkoists are *not* decisive for their interpretations. The experiments performed with two of their three methods lack the necessary controls and precautions; and the third method gives results in complete agreement with neo-Mendelism, without providing any evidence warranting a different interpretation. (2) No observations have been reported by the Lysenkoists which, when stripped of interpretation, cannot be accounted for by the previous well-tested principles of neo-Mendelism. (3) The Lysenkoists' interpretations do not provide a simpler or more reasonable explanation for the facts of genetics; on the contrary, they provide no explanation whatever for most of these facts.

Implications of Recent Work on Paramecium

However, regardless of whether the work of the Lysenkoists justifies their interpretation, recent work of others—particularly on the genetics of microorganisms—has been held in certain quarters to lead to the same conclusions, namely, that neo-Mendelism is invalid and that acquired characters are inherited. In the time at my disposal, I cannot discuss all the works that have been cited in this connection, so I choose from among them two recent investigations by my associates and myself on the unicellular animal *Paramecium* (*15*). for these are representative and illustrate well the main points.

The first investigation concerns the killer trait. Killer strains of paramecia liberate into their culture medium a substance that, under ordinary circumstances, kills paramecia of other strains, known as "sensitives." The killer and sensitive traits are hereditary through vegetative reproduction, self-fertilization, and conjugation between two that are alike in these traits; but when two that are unlike are crossbred, these traits follow the cytoplasm in inheritance.

The killer trait has been shown to depend upon the presence of visible, cytoplasmic particles, called kappa, of which there are a number ranging from hundreds to a thousand or more in the cytoplasm of each cell in a killer strain, but none at all in the cytoplasm of the cells of a sensitive strain (*10, 11*). These kappa particles multiply and never arise *de novo*; they can mutate and then reproduce true to the mutant form (*3, 4*). Here, then, is a particle that determines a hereditary trait of the paramecia, but is not a nuclear Mendelian gene.

Moreover, environmental conditions can alter this trait through their action on kappa (*5, 10, 13*). X-rays, nitrogen mustard, temperature and, even the amount of available food can bring about decreases in the amount of kappa (*10*) until in some paramecia none is left at all. This is an irreversible transformation of hereditary killers into hereditary sensitives. The reverse change can also be brought about experimentally by removing kappa from the bodies of killers, concentrating it in a dense suspension, and exposing sensitive paramecia to the suspension of kappa particles (*15*). The sensitives take up into their cytoplasm one or a few particles of kappa, which multiply and persist in their bodies and in the bodies of their descendants, making hereditary killers of them.

Up to this point, the killer trait seems to be outside the realm of Mendelian genetics; but the divorce is not complete. Kappa cannot multiply or be maintained in a paramecium unless certain genes are present in the nucleus. One main gene, *K*, must be pres-

ent and at least one other gene, *s*, is involved in a less conspicuous way (*14*).

How does this analysis of the inheritance of the killer trait bear on the Lysenko controversy? In the first place, like other investigations, it demonstrates the existence of material particulate bases of heredity outside the chromosomes in the cytoplasm. Regardless of how rare or how common such particles may turn out to be, regardless of whether they are considered normal or abnormal, regardless of whether they are labeled "plasmagenes," "viruses," or "symbionts," the fact remains that they underlie and determine processes which cannot logically be excluded from the category of inheritance.

The demonstration of inheritance determined by plasmagenes is used by Lysenkoists as support of their contention that the chromosome theory of heredity is not valid. The argument employed is the same as one of those used against the Mendelian 3:1 ratio: any exception to a rule disproves the rule. Thus, if inheritance is sometimes not due to nuclear genes, then, they conclude, it can never be due to nuclear genes. The fact is, on the contrary, that there are two distinct categories of inheritance, Mendelian and non-Mendelian, as has been known for forty years. Further, the plasmagene kappa is actually dependent upon Mendelian genes for its maintenance. The work on plasmagenes serves to show that there are two kinds of genes, nuclear and cytoplasmic; it is therefore merely an addition to, not in any sense a replacement of, neo-Mendelism.

It may be supposed that the demonstration of plasmagenes supports the view of the Lysenkoists that other parts of the cell than the chromosomes are the materials of heredity. Such a conclusion is based, however, on a fundamental misunderstanding of the Lysenkoist view. The Lysenkoists deny the existence of any special substance of heredity and therefore reject the plasmagene along with the nuclear gene. They will not admit that control of any particular hereditary trait is localized in any particles, either in the nucleus or in the cytoplasm. Hence, the demonstration of plasmagenes not only fails to support Lysenkoism, but is at variance with their views.

The second point of contact between the work on killer paramecia and Lysenkoism is with respect to the inheritance of acquired characters. A number of environmental agents can transform killers into sensitives or sensitives into killers and these changes are inherited. Is this the inheritance of acquired characters? For acquired characters to be inherited in *Paramecium*, acquired traits must be transmitted through sexual reproduction. Usually, only a nucleus passes into the mate during conjugation and it does not carry kappa. Under certain conditions, however, not only the migratory pronucleus, but also some cytoplasm passes into the mate during fertilization and then kappa may be carried across in the cytoplasm. Under these conditions acquired changes with respect to the killer trait may be inherited.

Even more instructive in this connection is the behavior of a plasmagene (the so-called "genoid," sigma) in the cytoplasm of the fruit fly *Drosophila* (*8*). Not only is it regularly transmitted by the egg and sometimes also by the sperm, but, more remarkably, it can migrate from body cells to the germ cells, which then pass it on to later generations. Plasmagenes that can migrate from soma to germ cells provide a possible mechanism for the inheritance of acquired characters. But it must be emphasized that such a mechanism is absolutely restricted to the relatively small class of non-Mendelian traits and, moreover, to the fraction of this class which is determined by migratory or "infectious" plasmagenes. So far as present knowledge goes, this fraction is so small that it is usually considered abnormal and migratory plasmagenes are often viewed as infectious viruses.

However, even if migratory plasmagenes should prove to be far commoner than now appears, this will not in the least invalidate neo-Mendelism. The phenomenon constitutes a further discovery about plasmagenes, which (as I pointed out earlier) are but an *addition* to genetics, not a *replacement* of any part of it.

Before leaving the subject of migratory plasmagenes as a possible mechanism for the inheritance of acquired characters, it should be emphasized that the same method used by L'Héritier to demonstrate that the *Drosophila* plasmagene could migrate from soma to germ cells, had been used by Castle and Phillips and by others for Mendelian traits of mammals and other organisms. The method is to transplant ovaries from individuals of one type to individuals of the alternative type and to see whether the eggs from the transplanted ovaries show any effects of having resided in an individual with a different heredity. This is, in effect, the animal equivalent of the Michurin graft hybrid technique. The important point here is that this method shows the complete independence of traits known to be determined by nuclear genes; they are in no way affected by the heredity of the host. Acquired characters are thus not inherited when traits are of Mendelian type, that is, when they belong to the class that includes the overwhelming majority of known hereditary traits.

In sum, the work on kappa in *Paramecium* and on other plasmagenes shows that acquired characters can be inherited if the characters fall in a certain subdivision of the non-Mendelian category. This, however, does not undermine neo-Mendelian genetics, for

it deals with an entirely separate category of phenomena.

I turn now to another investigation from our laboratory, one which is still in progress. It deals with antigens, specific chemical substances carried by the paramecia. These result in the immobilization or paralysis of the paramecia when the paramecia are brought into contact with specific complementary substances, called antibodies, obtained in the serum of rabbits immunized against these paramecia. The type of immobilization antigen carried by a paramecium is a hereditary trait and many different strains of paramecia differing in their immobilization antigens are known.

By several environmental means, the paramecia can be transformed so that they replace one kind of hereditary immobilization antigen by another one (*14, 16, 18*). Repeated transformations have yielded as many as eight different hereditary antigenic types from the progeny of one original paramecium. Moreover, by choosing appropriate environmental conditions, it has been possible to *direct* the transformations to one particular antigenic type among the eight possibilities (*16*). As one of the agents used to bring about these transformations is specific immobilizing antiserum which, in high concentration, is capable of killing the paramecia, and as the transformed organisms can be completely resistant to this agent, the transformation response is adaptive, although the adaptation is to an environmental agent seldom or never normally encountered in the life of a paramecium.

The mechanisms involved in the inheritance of the antigenic types are still not fully known. The nuclear genes clearly play a part in this, as is shown when different races are crossbred (*16, 17, 19*). The series of antigenic types producible is different in such different races. The genes control what kinds of antigens can be produced in a race and also the detailed structure of the antigens; in other words, they determine to what types the animals of a given race can be transformed. But the different types within one race are all alike in their genes and these differences are cytoplasmically inherited. Thus far it has been impossible to demonstrate that this cytoplasmic inheritance is by means of plasmagenes; an entirely different and as yet unknown mechanism of cytoplasmic inheritance may be involved. The role of the transforming environmental agents is clearly to bring about shifts from one to another of the several possibilities determined by the nuclear genes.

So far as the bearing on Lysenkoism is concerned, I shall not take the time to discuss again those features of the antigen system which are similar to the killer system already discussed, but shall pass at once to the new features. The first is the relation between environmental effects and nuclear genes. Here the nuclear genes, which Lysenko does not recognize, are the ultimate masters of the situation: the environment can transform only to a type for which the corresponding gene is present—a result which finds no place in Lysenkoism.

But the main new feature of the antigen work is that specifiable environmental conditions can force upon the cells specifically adapted and directed responses which are thereafter inherited through the cytoplasm. These acquired characters are sometimes transmitted to mates in sexual reproduction when massive amounts of the cytoplasm pass across to the mate during conjugation, as happens rarely. Since we have thus far been unable to obtain decisive evidence that the physical basis of this cytoplasmic inheritance is plasmagenic, it is possible that acquired characters in a unicellular organism may be transmitted by a mechanism other than that of an infectious plasmagene.

However, unicellular organisms are in a unique position in relation to the inheritance of acquired characters. Unlike multicellular organisms, they have whatever may correspond to soma and germ plasm within the confines of a single cell; and in many species of unicellular organisms, any cell can function either as a vegetative or a sexual cell. Hence, whatever results are obtained on these creatures by reason of these two unique features should not be extended to multicellular organisms without further evidence.

On the other hand, the results with *Paramecium* do bring out two fundamental facts that are critical for the Lysenkoist views. First is the fact of localization of decisive genetic determinants in different parts of the cell. In the two examples of inheritance of acquired characters, the decisive determinants are localized in the cytoplasm and are never transmitted by the nucleus. Such localization is contrary to Lysenkoism, which holds that each part of the cell—including the chromosomes, and presumably each part of every chromosome—is the material basis of the *entire* heredity of the cell.

Second, changes in the cytoplasm do not bring about corresponding (or any yet detected) changes in the gamete nuclei. Gamete nuclei produced in a cell with altered cytoplasm do not carry or transmit the change in heredity. This is shown not only by the two investigations referred to here, but also by three other investigations in which I have studied acquired characters. According to Lysenko, on the contrary, a genetic change in any region of the cell should be carried and transmitted by any part of the cell. In view of these results on the unicellular *Paramecium,*

how much less would one expect to find changes in the body cells of higher organisms transmitted to germ cells not derived from them, particularly to the nuclei of those germ cells.

Our work on *Paramecium* thus yields three main results all of which are in opposition to the claims of the Lysenkoists. First, the examples of cytoplasmic inheritance show that even this is closely tied up with the system of nuclear genes. Second, a special substance of heredity, which Lysenko does not admit, also underlies even some cases of cytoplasmic inheritance. Third, changes in the cytoplasm have no effect on the gamete nuclei.

However, we do find, in the work on cytoplasmic inheritance, evidence for the inheritance of acquired characters, but only when the characters belong to that very small class which is determined by migratory plasmagenes (or viruses) or when the characters occur in unicellular organisms. It is conceivable, but not yet demonstrated, that similar (but not identical) phenomena could occur in plants, because the germ cells arise from various parts of the plant body relatively late in the life history. Since the germ cells would, in this case, be lineally descended from the cells manifesting the acquired trait, the term "inheritance of acquired characters" is strictly speaking not applicable to this hypothetical situation. And it is important to be very clear that, for nearly all hereditary traits in all kinds of organisms—those which are determined by nuclear genes—there is as yet no convincing evidence that acquired changes are ever inherited.

In sum, there is no legitimate scientific ground for the Lysenkoists' rejection of neo-Mendelism and the chromosome theory of heredity. Their ideas are not supported by their own inadequately controlled experiments, and they are contradicted by the controlled experiments of others. Further, recent work on cytoplasmic inheritance, sometimes cited in support of Lysenko, yields results in fundamental opposition to his views. Even the inheritance of acquired characters, which occurs in some of these cases, holds only for a small class of exceptional traits and does not apply at all to the usual gene-controlled traits. The Lysenkoist "new genetics" is thus not scientifically justified.

The Lysenkoists' Response to Criticism

Do the Lysenkoists know the criticisms that have been raised about their experimental work? If so, what have they done about them? The Lysenkoists do know the criticisms that have been raised concerning their experiments; they have been pointed out repeatedly by the Russian geneticists themselves. However, this has not led to repetition of the experiments in such a way as to avoid the most serious errors. Their response to criticism can be best illustrated in their own words:

> . . . bourgeois biologists abroad can console themselves only by saying that Soviet biologists can get easy results from intravarietal crosses of self-pollenaters because the varieties used in Russia are "not pure." However, such a laughable appeal "to the impure" [Russian pun, meaning "to the devil"] when speaking of a good, full, valuable scientific life, is in vain. [Reference *12*, p. 18.]

> . . . there are some faithful Morganists who try to deny the facts that overthrow Morganism. They keep in store, as ready answers to all experimental data that disprove their theory, either the general excuse of "impurity" of original stock, or just one word: mutation. [Reference *12*, p. 22.]

No further discussion of impurity is to be found; no citation of controlled experiments; no acknowledgment that they are needed. The mere statement that "impurity" is the usual and general objection is apparently considered to be quite enough to dispose of it.

As scientists, we are all in agreement that the final test of the acceptability of experimental data is independent repetition. We have seen that independent experiments performed outside of Russia (and also many performed in Russia) have failed to confirm the results of the Lysenkoists. To this, the Lysenkoists reply: The proper technique was not employed. Yet they will not specify what the proper techniques are in such a way that others can employ them. One of their own geneticists made this clear during a debate on this subject in Russia in August, 1948. He said:

> I want to make a personal request of Trofim Denisovich [Lysenko]. Trofim Denisovich, instruct your organization to issue a comprehensive manual on how to train plants, on how to alter them. Teach us; we too want to learn, and if your methods prove effective, we will accept them. [Reference *21*, p. 466.]

With this modest and basic request, the rest of the world of science can only join. I therefore challenge the Lysenkoists, as did their own Soviet neo-Mendelist, to provide detailed descriptions of methods so that their assumed revolutionary findings can be independently tested by others. I further challenge them to repeat their own experiments with the controls demanded by their critics and to publish the results with full numerical data so that others can analyze them for statistical significance, even if they themselves refuse to do so. If the future may be judged by the past, neither of these challenges will be accepted.

Standards of Scientific Validity

As scientists we must inquire further as to why such challenges have not been accepted and as to why the same experiments look so different to Lysenkoists and to us. A full discussion of this aspect of the Lysenko controversy is beyond the scope of this paper. It can be found in the little booklet of Hudson and Richens and in the two recent books by Zirkle (*20*) and Huxley (*7*). Those who wish to deduce the answers for themselves from the original sources can readily do so by reading *The Situation in Biological Science* (*21*), a large book containing the official Russian translation into English of the Proceedings of the Lenin Academy of Agricultural Sciences of the USSR, for the meeting held July 31 till August 7, 1948. From these sources it will become evident that the standards of scientific validity employed by the Lysenkoists are entirely different from those accepted elsewhere in the world.

The Lysenkoists, in brief, employ the following standards: (1) appeal to authorities, recognized and approved by them, such as Darwin, Michurin, and Burbank; (2) rejection as heresies views that can be represented as inconsistent with an approved authority; (3) rejection of evidence if the worker can be represented as badly motivated or under disapproved influences, for example, by maintaining that he is a reactionary, an idealist, bourgeois, or a foreigner; (4) testing the validity of a theory by the speed and frequency with which adherents of the theory produce practically useful results.

Not only are these standards of scientific validity, which we consider irrelevant, employed, but our standard of objective evaluation of evidence is expressly abjured. Thus, Y. Zhdanov of the science department of the Central Committee of the Communist Party, in a letter addressed to Stalin, appealed to Lenin as authority for "the danger of falling into objectivism" which Zhdanov confessed as one of his own faults derived from his "regrettable 'university habit' of not hesitating to express my own point of view in a scientific argument" (*7*, p. 228). This he promised to correct.

Of all the scientific standards recognized by the Lysenkoists as valid, perhaps none is more important than agreement with the philosophy of dialectical materialism. In perusing the great debate of August, 1948, it will be noted that *both* sides, the Mendelian geneticists and the Lysenkoists, attempted to show how their views were consistent with dialectical materialism.

The reason is that dialectical materialism is the official philosophy of the Communist Party and the Soviet Government. It is obligatory that scientific work should appear to conform with it, or at least that it shall not be shown to be at odds with it. Ashby (*1*), in his book *Scientist in Russia*, reports that most scientists of the older generation manage in a perfunctory way to appear to conform although they continue really to employ the same scientific standards as we do. The Lysenkoists, on the other hand, have used conformity with dialectical materialism as a powerful means of enlisting support for their own views and for discrediting the work of the Mendelians.

Politics and Science

Through dialectical materialism, science in Russia maintains an intimate and ever threatening contact with politics. This philosophy is the official philosophy of the state and it is supposed to guide science in ways that Lenin and other leading Communists have pointed out. That this connection between politics and science can be disastrous for science is illustrated well by the events recorded in the proceedings of the August 1948 conference to which I have referred. At the close of the conference, Lysenko, president of the Academy, introduced his concluding remarks with the following (*21*, p. 605):

> Comrades, before I pass to my concluding remarks I consider it my duty to make the following statement.
>
> The question is asked in one of the notes handed to me, What is the attitude of the Central Committee of the Party to my report? I answer: The Central Committee of the Party examined my report and approved it. (Stormy applause. Ovation. All rise.)

Towards the end of this speech, Lysenko added (*21*, p. 617):

> The Party and the Government are showing paternal concern for the strengthening and development of the Michurin trend in our science, for the removal of all obstacles to its further progress.

Following this statement, three of Lysenko's opponents, who had argued in defense of what is known as genetics everywhere else in the world, recanted their opposition and pledged support to what had been announced as the doctrine to be supported by the party and the government. Let us examine the reasons given for their recantation. Academician Zhukovsky said the following:

> The speech I made the day before yesterday, at a time when the Central Committee of the Party had (unknown to him) drawn a dividing line between the two trends in biological science, was unworthy of a member of the Communist Party and of a Soviet scientist. [Reference *21*, p. 618.]
>
> I consider it to be my moral duty to be a sincere Michurinist, a sincere Soviet biologist. [Reference *21*, p. 619.]
>
> It has been said here (and the reproach is deserved) that we do not conduct a fight in the press against foreign reactionaries in the field of biological science. I declare

here that I shall conduct that fight, that I attach political importance to it. [Reference *21*, p. 619.]

I take this step today as a Party member, as a sincere member of our Party—that is, honestly. (Applause.) [Reference *21*, p. 620.]

I have not omitted any part of the speech that states a single scientific reason for recanting, or any implication that the decision was based on anything but the one fact that the Communist Party and Government had declared for Lysenkoism.

From the second speech of renunciation, by S. I. Alikhanian, I quote (*21*, p. 62):

From tomorrow on I shall not only myself, in all my scientific activity, try to emancipate myself from the old reactionary Weismann-Morganian views, but shall try to reform and convince all my pupils and comrades.

There is no denying that this will be an extremely difficult and painful process. Many perhaps will not understand this; but then there is nothing to be done—our way and their way will part. It will mean that they cannot appreciate the assistance the Party has rendered us in this radical turn which has taken place in science....

From the third speech of renunciation, by I. M. Polyakov, I quote (*21*, p. 623):

It is necessary to understand the chief and fundamental thing, namely, that our Party has helped us to effect a profound and radical reconstruction of our science, has shown us that the Michurin theory defines the basic line of development of Soviet biological science, and from this we must draw the conclusion and work to promote the Michurin trend.

My quotations need no commentary. They show better than any citation of facts or arguments why neo-Mendelian genetics has disappeared from the Soviet Union. It is strictly a political matter and has nothing to do with scientific evidence as known elsewhere in the world. I urge all who may still be in doubt to read themselves the book which the Soviets have translated and spread abroad. To them it is natural and right that the state or the party should decide what is correct and permissible in science and should root out and suppress all that fails to conform. The Mendelian geneticists who were members of the party had to choose between setting science above the party or the party above science. The latter was their choice, as they clearly set forth in their speeches of renunciation. As they said, it is difficult, but not impossible to readjust their science to suit the will of the party. In view of this, let the Communists of our own country be as truthful and frank as the Communist geneticists of Russia and confess that they support Lysenko because the party supports him; that it is quite irrelevant whether he has or has not given adequate experimental support to his biological pronouncements; that his science must be correct because the party has decided that only his views of biology are consistent with dialectical materialism.

I have yet another quotation to add; it is from *Pravda*, August 27, 1948.

The Praesidium of the Academy of Science and the Bureau of the Biological Department forgot the most important principle in any science—the Party principle. They pegged themselves to a position of political indifference and "objectivity."

In Huxley's excellent, brief, and pointed summing up of the situation (*7*, p. 234):

The issue could not be stated more clearly: Do we want science to continue as the free pursuit of knowledge of and control over nature, or do we want it to become subordinate to political theory and the slave of national governments? It is a crucial question, on which the general public as well as the professional scientist must make up its mind.

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Technical Papers

The Incidence of Bacteremia in Mice Subjected to Total Body X-Radiation[1]

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Infection has been described as one of the features of radiation sickness (*1–4*) but its role has not been systematically investigated heretofore. This paper reports a study of such infection.

Methods. Male Swiss mice,[2] weighing 18 g to 22 g and obtained from an inbred stock, were subjected to total body x-radiation in a single exposure, delivered at 20 kv, 15 ma, at a distance of 27 in., using ½-mm copper and 3-mm Bakelite filter.[3] Their LD_{50} (30 days) was approximately 400 roentgen units. They were housed in a room kept at a temperature of 73°–78° F.

TABLE 1

SUMMARY OF EXPERIMENTS

Dose r	No. mice irradiated	Mice cultured	Total cultured
600	585	20 per day, 2nd–15th days after irradiation	280
450	1042	35 per day, 2nd–18th days after irradiation	595

Two series of mice were studied: one received 600 r, the other 450 r. Each series consisted of a number of groups, all the members of which were irradiated on a single day. Beginning the second day after irradiation, several (usually 5) mice in a group were killed and cultured daily until the desired number of cultures for each postirradiation day had been obtained (see Table 1). Of 585 mice irradiated with 600 r, 280 were killed and cultured; of 1,042 irradiated with 450 r, 595 were killed and cultured.

Cultures. None of the cultures reported here was made on mice that had died. Each mouse to be cultured was etherized and autopsied immediately. The chest was opened under aseptic precautions and heart blood aspirated with a capillary pipette. A drop (approximately 0.05 ml) was planted on the surface of nutrient agar and blood agar plates and carefully spread with a sterile loop. In the 450-r series, the remainder of the heart blood was inoculated into 5 ml of brain-heart infusion broth. The spleen was removed and cultured in brain-heart infusion broth. In the 600-r series, the spleen was also cultured on nutrient agar and blood agar plates, but in the 450-r series, only broth cultures were made.

Anaerobic cultures of blood from 25 hearts in each series were made in Brewer's fluid thioglycolate media. Blood and spleen of 62 additional animals in the 450-r series were cultured in tubes of brain-heart infusion media under NaOH and pyrogallic acid. Only one true anaerobe was recovered; it was isolated from the spleen of a mouse on the 16th day after irradiation.

Control cultures on normal mice. Blood and spleens of 35 normal mice from the same stock, cultured by the routine procedure for the 450-r series, were all sterile. The spleens of 17 additional mice were ground individually in a Waring Blendor and cultured aerobically and anaerobically. All of these cultures were also sterile.

TABLE 2

RESULTS OF BLOOD AND SPLEEN CULTURES ON MICE SUBJECTED TO 600 R TOTAL BODY X-RADIATION*

Days after irradiation	Daily death rate† %	Blood and spleen positive No. of mice	Spleen only positive No. of mice	Blood *or* spleen positive %
2	0	1	0	5
3	0.3	1	0	5
4	0.5	0	0	0
5	2.0	1	0	5
6	4.0	9	0	45
7	3.0	11	0	55
8	6.0	10	0	50
9	9.0	17	0	85
10	7.0	12	0	60
11	6.0	15	0	75
12	4.0	11	0	60
13	3.0	8	1	45
14	2.0	6	0	30
15	0.6	3	3	30

* Twenty mice killed and cultured each day after irradiation. Cultures on mice that died spontaneously are excluded from these data.

† Percent of total number irradiated.

Results. In the 600-r series, a total of 280 mice were killed and cultured. Table 2 presents the results of the blood and spleen cultures and also the daily mortality rate based on the total of 585 mice receiving this dose of radiation. The highest daily incidence of positive cultures (85%) occurred on the 9th day, which was also the day on which the greatest number died (9%). A rough estimate of the severity of the bacteremia was obtained from colony counts of plate cultures seeded with a single drop of blood. Seventy percent of the positive cultures contained more than 50 colonies and 35% of them innumerable colonies.

[1] This investigation was initiated as part of the U. S. Army Contract No. W49-007-MD-425 and has been continued under Contract No. At(11-1)-46 between the U. S. Atomic Energy Commission and the University of Chicago.

[2] From an old colony maintained by the Maple Grove Rabbitry, Springfield, Missouri.

[3] All of the mice were irradiated at the Argonne National Laboratory, with the assistance of Mr. Joseph Trier and Mr. Emil Johnson. The authors are indebted to them and also to Dr. Austin M. Brues, director of the Biology Division of the Argonne National Laboratory, for many helpful suggestions.

TABLE 3

RESULTS OF BLOOD AND SPLEEN CULTURES ON MICE SUBJECTED TO 450 R TOTAL BODY X-RADIATION*

Days after irradiation	Daily death rate† %	Blood and spleen positive No. of mice	Spleen only positive No. of mice	Blood *or* spleen positive %
2	0.2	1	2	8
3	0	0	0	0
4	0	1	5	17
5	2.0	0	3	8
6	1.0	4	1	14
7	4.2	3	1	11
8	4.3	8	1	25
9	4.6	4	2	17
10	6.0	15	4	54
11	3.6	15	2	48
12	4.0	15	2	48
13	3.0	13	3	45
14	1.0	12	1	37
15	0.8	8	3	31
16	0.2	10	3	36‡
17	0.1	3	0	8
18	0	5	1	17

* Thirty-five mice killed and cultured each day after irradiation. Cultures on mice that died spontaneously are excluded from these data.

† Percent of total number irradiated.

‡ One anaerobe.

In the 450-r series, a total of 595 mice were killed and cultured. Table 3 shows that a high incidence of positive cultures occurred during the period of greatest mortality, although the maxima were not as great as in the preceding series. The daily mortality rate was based on the total of 1,042 mice irradiated in this series. The bacteremia was not as severe; approximately 70% of the positive cultures developed more than 50 colonies but only 20% contained too many colonies to count.

TABLE 4

CLASSIFICATION OF MICROORGANISMS RECOVERED FROM HEART BLOOD OR SPLEEN OR BOTH

	%
Paracolobactrum	42
Coliform	22
Proteus	13
Pseudomonas	9
a Streptococcus	6
Unidentified Gram-negative rod	3
Alcaligenes	2
Anaerobes	0.3

Identity of the organisms. The cultures were identified by the customary methods. The relative frequence of the various species is given in Table 4. In a systematic survey of the flora at different levels of the intestinal tract of normal mice it was found that all of the species listed in Table 4 occurred regularly in the large bowel with the exception of *Pseudomonas.* This organism was found only occasionally. It is clear from these findings that the lower intestinal tract was the reservoir from which invasion of the blood stream occurred. In both the 600-r and 450-r series, 91% of the cases of bacteremia were caused by a single organism; in the remaining 9% no more than two species were present. This fact strongly suggests that multiplication of the organisms was occurring in the blood stream.

It was during the second week after irradiation, the period of greatest mortality, that bacteria from the lower intestinal tract invaded the blood stream and produced bacteremia, often of great severity. The maximum incidence of such infections in mice exposed to 600-r or 450-r x-radiation was 85% and 54%, respectively.

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The Effect of Cobalt on the Microbial Synthesis of LLD-active Substances

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Shorb (*7*) reported an unidentified growth factor in liver extract, LLD, which is required by *Lactobacillus lactis* Dorner. Crystalline vitamin B_{12}, a cobalt coordination complex isolated from liver (*5*), was found capable of satisfying the LLD requirement of this organism (*8*). It has also been shown that *Lactobacillus leichmannii* responds to vitamin B_{12} (*2*). Recently Rickes *et al.* (*6*) have reported the isolation of crystalline vitamin B_{12} from culture broths of a grisein-producing strain of *Streptomyces griseus.* In addition, they reported the presence of LLD-active substances in culture broths of other microorganisms. Other investigators have also observed the presence of materials having growth-promoting activity for *L. leichmannii* in various microbial broth cultures (*1, 4*). During an extensive screening program we have observed that large numbers of microorganisms are capable of synthesizing LLD-active substances. Chemical extraction data and paper strip chromatography carried out on some of these broths have shown them to contain vitamin B_{12}.

Various medium modifications were investigated in an attempt to increase the microbial synthesis of vitamin B_{12}. This paper presents the data obtained from a study on cobalt supplementation.

Medium. The medium employed in these studies was composed of 1% N-Z-Amine (Type A),[1] 0.3% Difco beef extract, and distilled water to volume. The medium was adjusted to pH 6.8–7.0 with NaOH, dispensed in 40-ml aliquots per 250-ml Erlenmeyer flask, and sterilized at 15 lb pressure for 20 min.

Inoculum. The various microorganisms were carried on nutrient agar slants. A 48-hr shake flask culture was used as inoculum in experiments with the grisein-produc-

[1] An enzymatic digest of casein manufactured by Sheffield Farms, Inc.

ing strain of *S. griseus*. In the case of the other microorganisms, a water suspension derived from a 24-to-48-hr agar slant was used as inoculum.

Incubation. The flasks were incubated for 5 days at 28° C on a shaking machine imparting a rotary motion of 220 rpm.

Estimation of LLD activity. Five-day-old fermentation broths were adjusted to pH 7.0 and diluted in distilled water to contain approximately 0.5 unit of vitamin B_{12} equivalent per ml. These samples were then assayed for LLD activity by the procedure previously outlined, using vitamin B_{12} as a standard (*3*).

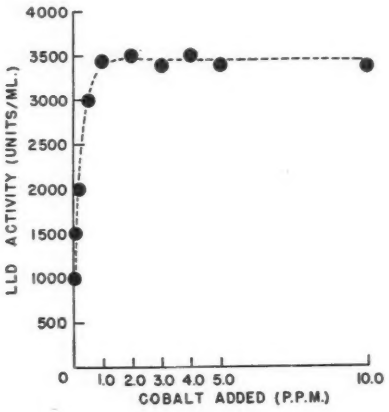

FIG. 1.

Experiments with S. griseus. In these experiments varying concentrations of cobalt in the form of $CO(NO_3)_2 \cdot 6H_2O$ were added to the N-Z-Amine medium prior to sterilization. LLD activity was then determined after 2, 3, 4, and 5 days' incubation. Maximum activity was observed between the 3rd and 5th days, with no significant loss in titer after peak production. For this reason, in these experiments, samples were assayed on the 5th day. Fig. 1 shows the response curve obtained with increased dosage of Co^{++}. An approximate threefold increase in LLD titer was obtained by the addition of Co^{++} to the basal medium. Although LLD activity is not identical with vitamin B_{12}, an increase in B_{12} production was also obtained which more or less paralleled the increase in LLD activity.[2] Maximal activities were obtained with as little as 1 to 2 ppm Co^{++}. Toxic manifestations became apparent at levels of 20 to 50 ppm Co^{++}. At these levels a marked decrease in growth and LLD activity was observed. It is apparent from these experiments that Co^{++}, a structural constituent of the B_{12} molecule, becomes the limiting factor in N-Z-Amine medium for the microbial synthesis of LLD-active substances. Supplementation of the medium with Co^{++} therefore gives rise to an increase in LLD activity and vitamin B_{12}.

Experiments with other microorganisms. It has previously been observed that microorganisms other than *S. griseus* produce significant yields of LLD-active substances (*6*). We have observed that a large number of microorganisms were capable of synthesizing LLD activity and that supplementation of the N-Z-Amine medium with Co^{++} (2 ppm) gave rise to increased yields of the growth factor. The results shown in Table 1 indicate the Co^{++} effect with several isolates obtained from cow rumen contents and manure, as well as with several cultures from the Merck Culture Collection. In every case, the addition of Co^{++} (2 ppm) resulted in a significant increase in the LLD titer of the broth.

TABLE 1

EFFECT OF Co^{++} ON LLD SYNTHESIS

Organism	LLD-active substances (units/ml)	
	No added Co^{++}	Co^{++} added (2 ppm)
R2*	1100	3500
R5	700	4900
R6	160	3000
R12	400	800
R36	1300	4800
R41	500	1140
C5†	260	480
C6	280	750
C7	390	950
C10	160	380
Mycobacterium smegmatis	540	3800
Pseudomonas sp.‡	640	3000
Streptomyces griseus G25	880	3500

* R series—isolates from cow rumen contents.
† C series—isolates from cow manure.
‡ Isolated from soil by J. W. Foster and tentatively named by him, *Pseudomonas lumichroma* n. sp., since it is capable of decomposing lumichrome.

These experiments throw some light on the biological significance of cobalt in the nutrition of the microbial cell. One role of cobalt, in the biosynthesis of vitamin B_{12}, has been experimentally substantiated with microorganisms.

In summary, data have been presented to show that, in N-Z-Amine medium, Co^{++} becomes the limiting factor in the biosynthesis of LLD-active substances by *S. griseus*. The addition of as little as 1 to 2 ppm Co^{++} gives rise to approximately a threefold increase in LLD activity.

In addition, an extensive survey has shown that large numbers of microorganisms synthesize LLD-active substances and that, in these cases as well, supplementation with Co^{++} (2 ppm) gives rise to a significant increase in LLD activity.

[2] We are indebted to E. L. Rickes and T. R. Wood for the isolation data.

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Formation of Pentose Phosphate from 6-Phosphogluconate[1]

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Early studies on the oxidation and degradation of 6-phosphogluconate appeared to establish the formation of pentose phosphate by yeast enzymes. Although it was cautiously suggested by Dickens (*3*) that ribose-5-phosphate was produced, the identities of the pentose and of the intermediates were not established. In view of the importance of the problem of the origin of ribose in nucleic acids and coenzymes, and of the nature of the shunted metabolism in virus-infected bacteria (*1*), we have reinvestigated this system.

TABLE 1

R$_F$ VALUES FOR SUGAR PHOSPHATES

Compound	Solvents		
	80% ethanol containing 0.8% acetate at pH 3.5		80% ethanol containing 0.64% boric acid
Glucose-6-phosphate	0.35		0
Fructose-6-phosphate	0.38		0
Glucose-1-phosphate	...		0
Glucose-4-phosphate	0.45		0
Ribose-5-phosphate	0.50		0
D-Arabinose-5-phosphate ..	0.54		0.25
D-Xylose-5-phosphate	0.55		0, 0.25
Ribose-3-phosphate	0.50		0, 0.19
Xylose-3-phosphate	0.53		0, 0.23
Glyceraldehyde-3-phosphate	0.73		0.92
	0.83	fluorescence	0.87
6-Phosphogluconate	0.89		.....

The action of yeast enzymes, prepared according to the method of Dickens and McIlwain (*4*), on 6-phosphogluconate was studied in the presence of TPN (triphosphopyridine nucleotide), phenazine as a hydrogen carrier, a 0.01 M phosphate buffer at pH 7.0, and 0.0067 M NaCN which promotes the oxidation. At the end of the reaction slightly more than 0.5 mole of O_2 was consumed per mole of substrate, and 0.5 mole of CO_2 was produced. It was found that 0.25–0.40 mole of new pentose accumulated in this system.

The end products and intermediates were fractionated as follows: Protein was removed with 5% trichloroacetic acid and the phosphate esters were isolated as Ba salts by precipitation in 80% ethanol. The esters were analyzed by paper chromatography in 80% ethanol containing 0.8% acetic acid at pH 3.5 or 0.64% boric acid. In Table 1, it may be seen that characteristic R$_f$ values were obtained for a large number of sugar phosphates. Boric acid has, in addition, provided a tool for distinguishing *cis*-hydroxyls, inhibiting the movement of ribose-5-phosphate but permitting the migration of D-arabinose-5-phosphate. In this medium, it was shown (Fig. 1) that 50% of the Bial-reactive phosphate formed does not have characteristics of either ribose- or arabinose-5-phosphate. A substance having R$_f$ values of ribose-5-phosphate was also observed. The formation of glyceraldehyde-3-phosphate and the disappearance of 6-phosphogluconate was also demonstrated as the reaction progressed.

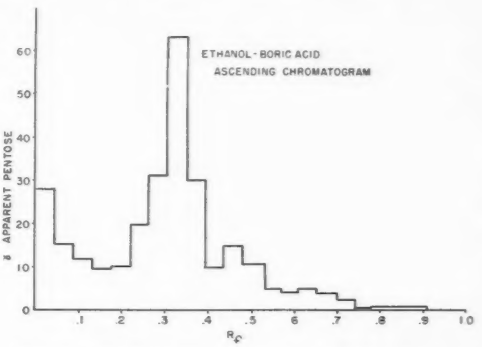

FIG. 1. Distribution of phosphorylated Bial-reactive carbohydrate in eluates of 1-cm strips of an ethanol-boric acid ascending paper chromatogram. The chromatogram was obtained on the isolated Ba salts after partial enzymatic degradation of 6-phosphogluconate. In this experiment the reaction was stopped after 40% of the theoretical O_2 has been consumed.

The pooled phosphate esters were hydrolyzed with alkaline phosphatase. The acids were adsorbed at pH 7 on the anion exchange resin, Amberlite IRA-400. Elution with 0.1 *N* HCl permitted the separation of gluconate and 2-ketogluconate. A 2-ketonic acid was observed in the eluates. Small amounts of a substance with the R$_f$ values and chemical reactivities of 2-ketogluconic acid were observed in paper chromatograms, after hydrolysis of the esters isolated at intermediate stages of the reaction.

The neutral sugars in the resin filtrate were found to contain substances with the R$_f$ values of ribose and possibly D-arabinose as determined on chromatograms with various solvents. R$_f$ values were established by color reactions or estimations of pentose in eluates of cuts of the chromatograms. Direct fermentative analysis in Warburg manometers of this filtrate by means of *E. coli* strains specifically adapted to ribose or D-arabinose (*2*) revealed ribose amounting to 25% of the pentose. By this method ribose was also found in eluates of the appropriate cuts of the chromatograms.

The data imply that this system contains enzymes for at least two reaction steps. At least one oxidation involving the disappearance of 0.5 mole of 6-phosphogluconate did not result in pentose formation. However, oxidation corresponding to the remaining 0.5 mole of substrate was followed by decarboxylation and pentose phosphate for-

[1] This research was conducted under Office of Naval Research Contract N6ori-188, Task Order 1, NR 136-055.

mation. The finding of ribose among these products indicates an inversion at some level in this series of reactions. The nature of the unknown Bial-reactive phosphate is of interest in this connection. Whether the triose phosphate arose from the pentose phosphate (*5*) or some other product is being investigated.

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Transplantation of Rabbit Blastocysts at Late Stage: Probability of Normal Development and Viability at Low Temperature[1]

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Following previous investigations on transplantation of rabbit ova at different stages (*1, 2*), the following experiment was performed. Rabbit blastocysts at late stage, 6 days after mating, were recovered from superovulated does (*7*) by flushing the excised uterus with fresh rabbit serum diluted with an equal volume of 0.9% NaCl. The percentage of recovery was very high, 75%–100%, as checked by counting the number of corpora lutea. The highest number of blastocysts recovered from one doe was 62. Most of the blastocysts measured 3 mm in diam, but a few of them measured 1 mm, probably due to the large number of ova produced by superovalation. Most of them were round in shape, and the germ disk appeared in the large ones. After recovery they were kept at 30° C in a watch glass placed inside a Petri dish no more than 45 min before transplantation.

Transplantation was performed by making a 5-mm longitudinal incision on the exposed uterus and by placing the blastocysts into the uterus with a pipette 4 mm in diam. The incision was closed with catgut sutures. Fifty blastocysts were transferred to seven recipients at the sixth day of pseudopregnancy, and six of the recipients gave birth to 21 normal young genetically resembling the donors. The gestation period was 26–27 days, and the percentage of blastocysts which developed into young in the pregnant recipients was 47.7.

The blastocysts, placed in a small tube containing serum diluted with 0.9% NaCl, were stored for 1 or 2 days at 10° C (at room temperature for 30 min before storage) or at 0° C (with acclimatization at 10° C for 2 hr). They were then cultured at 38° C in a Carrel flask containing undiluted serum. The results are presented in Table 1. After storage for 1 day at 10° C about one-third of them were shrunk, their round shape lost, but practically none shrank at 0° C for 1 day. After storage for 2 days, either at 10° or at 0°, most of them were collapsed, with separation of trophoblast and albumin coat, and had sunk to the bottom of the tube. In culture, it took about 12 hr for the shrunken blastocysts, or about 24 hr for the collapsed blastocysts, to recover their round shapes. Their growth was observed by enlargement in size and appearance of the primitive streak (or neural groove in two cases) after 3 days' culture.

TABLE 1

VIABILITY OF RABBIT BLASTOCYSTS AT LOW TEMPERATURE

Storage temperature in °C	Storage time in days	No. stored	% Shrunk or collapsed	No. cultured	No. recovered	No. grown
10	1	36	36	15	11	8
	2	39	87	25	19	6
0	1	37	3	9*	5	3
	2	11	91	6	0	0

* Eight of nine shrank in culture on the first day, five of eight recovered their round shape on the second day.

It is interesting to note that no blastocysts recovered in culture after storage at 0° C for 2 days, and that some intact blastocysts after storage at 0° C for 1 day shrank in culture on the first day and recovered on the second day. Very few of them resumed their growth. A temperature of 10° C is therefore better for the storage of blastocysts at the late stage, just as in the case of ova at an early stage (*1*).

Following these observations, 18 blastocysts after storage at 0° C for 1 day (all intact) were transferred to three recipients at the fifth and sixth days of pseudopregnancy. None was diagnosed as pregnant by palpation. At laparotomy, one small swelling on the uterus (indicating maternal placental formation) of one recipient was observed. Twenty-three blastocysts after storage at 10° C for 2 days (18 shrunk, five intact ones) were transferred to three recipients. Three swellings of different sizes but without normal embryos (indicating degeneration of embryos at different stages after placental formation) were observed in two of the recipients. Twenty-eight blastocysts after storage at 10° C for 1 day were transferred to five recipients. The first, which received four blastocysts, did not become pregnant; the second, which received four intact ones, had two large swellings as well as two small swellings at laparotomy and gave birth to two young at term; the third, which received three intact and four shrunken ones, had six normal embryos, 7–9 mm, when examined 6 days later. The last two animals each gave birth to two normal young 28 days after transfer. The percentage of development of blastocysts in the pregnant does was therefore 50.

The viability of blastocysts at different stages *in vitro* may not be the same. Most of the blastocysts which

[1] This investigation was supported by a grant from the Committee on Human Reproduction, National Research Council, acting on behalf of the National Committee on Maternal Health. Thanks are due to Dr. G. Pincus for encouragement during this study.

were recovered from the uteri 4 days after mating shrank in serum within 15 min at 30° C, but none of the large 6-day-old blastocysts shrank under this condition. It seems that 4-day-old blastocysts are more delicate than 6-day-old ones.

TABLE 2

DEVELOPMENT OF TRANSFERRED RABBIT OVA OR BLASTOCYSTS AT DIFFERENT AGES AND AFTER STORAGE AT 10° C FOR 1 DAY*

Age of ova in days	Ova transferred	Recipients used	Recipients pregnant	Young obtained	% Development of all ova transferred	Site of recovery and transfer
1	239	24	21	130	54	From tubes
Stored	94	7	4	35	37	to tubes
2	76	7	5	17	22	From tubes to uteri
3	132	11	5	41	31	From tubes
Stored	103	7	6	38	37	or uteri to uteri
4	167	17	13	71	43	From uteri
Stored	138	8	7	26	19	to uteri
6	50	7	6	21	42	From uteri
Stored	28	5	4	12	43	to uteri

* Transplantation at the corresponding stage of ova and corpora lutea.

In order to show the probability of normal development of transferred ova or blastocysts at different stages, and after low temperature storage, the data published previously (*2*) and the data accumulated in a recent study on the development and fate of transferred ova in relation to the ovulation time of recipients (*3*) were pooled and are presented in Table 2. After direct transfer to the portion of the tract normal for a given stage, the percentage of transferred ova developing into young varies from 31% (3-day ova) to 54% (1-day ova), indicating no very great variation in transplantability from stage to stage. Although storage at low temperature may reduce the viability of transferred ova (e.g., 4-day blastocysts), this is not invariable, so that 24-hr storage under the conditions we have employed appears to have no markedly deleterious effect. The low percentage of development in the case of 2-day-old ova is probably owing to the fact that ova were recovered from the tubes but transferred to the uteri.

The development of transferred ova in rabbits (*5, 8, 9*), in rats (*6*), and in mice (*4*) has been reported. So far as the writer is aware, this is the first report on the successful transplantation of blastocysts at a late stage. Technically, the recovery of tubal ova and transplantation of ova to the tubes of recipients require delicate surgery, whereas the recovery of ova or blastocysts from the uterus and transfer to the uterus of a recipient can be performed without surgery in large farm animals. The present study demonstrates this possibility. These findings have an application in the experimental study of early development in mammals.

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Brucella Agglutinin-blocking Phenomenon in Bovine Sera[1]

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Recently Griffitts (*1*) demonstrated the existence of an agglutinin-blocking property, sometimes called "incomplete antibody," in sera from known cases of human brucellosis. His work was prompted by reports of Wiener (*5*), Race (*4*), Levine (*3*), and others on the agglutinin-blocking phenomenon in sera of individuals sensitive to the Rh factor, and by the absence of agglutinins in significant concentration in a number of individuals known to have brucellosis.

The agglutination test is probably the most extensively used diagnostic procedure in both human and bovine brucellosis. Its diagnostic usefulness in bovine brucellosis may be even greater than in human brucellosis, since certain critical titers have been established designating an individual animal as a reactor, suspect, or nonreactor. Therefore, the existence of agglutinin-blocking substances in bovine sera could be of considerable diagnostic—and economic—importance. Although this blocking phenomenon has been encountered in human brucellosis sera (*1*), reports of its occurrence in bovine sera have not appeared in the literature. The following experiments demonstrate the presence, in significant concentration, of such agglutinin-blocking substances in bovine sera.

A study of the agglutinating and agglutinin-blocking properties was made on the sera of animals of five bovine herds. Three separate tests were carried out on each serum at repeated intervals: First, a double-dilution tube-agglutination test with dilutions in 0.9% saline beginning with a dilution of 1: 2. The last tube contained no serum and served as a control. The total volume of serum dilution-antigen mixture per tube was 1.0 ml. Tubes were incubated at 37° C for 2 hr and read after remaining in the refrigerator overnight. Second, an agglutinin-blocking test, consisting of the addition to each tube in the tube-agglutination test of 0.1 ml of known complete *Brucella abortus* rabbit antibody in a dilution such that complete agglutination occurred in the saline controls after further incubation at 37° C for 2 hr and refrigeration overnight. Third, a rapid macroscopic agglutination test, with the

[1] Authorized for publication as paper No. 1545 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

bacterial cells suspended in 12% saline, following essentially the method of Huddelson and Abell (*2*). The S-19 strain of *Brucella abortus* was employed in preparation of antigens and antisera.

Two of the five herds studied, consisting of a total of 36 animals, were considered clinically free of brucellosis. In addition, most of the animals had been previously tested at intervals for significant *Brucella* titers. Only one of the animals in these two herds had been previously vaccinated against brucellosis, and it showed a tube agglutination titer of 1: 256 and a rapid macroscopic titer of 1: 320. None of the remaining animals showed tube-agglutination or rapid-macroscopic titers of more than 1: 40, and none of the 36 sera possessed agglutinin-blocking properties.

TABLE 1

AGGLUTININ AND AGGLUTININ-BLOCKING TITERS* IN NINE SELECTED BOVINE SERA

Animal	Tube-agglutination titer		Blocking titer		Rapid-macroscopic titer
	Complete	Partial	Complete	Partial	
R1	0	8	32	128	640
R2	0	0	128	256	640
R5	0	0	1024	4096	640
R17	0	0	128	0	640
R18	0	0	128	256	640
R37	0	0	128	512	640
R38	0	0	256	1024	640
R40	0	16	128	1024	640
S3	0	0	32	0	640

* Expressed as reciprocals.

Three of the five herds, consisting of a total of 52 animals, had never been vaccinated or tested and were considered to be clinically "suspicious" of harboring *Brucella*-infected animals. Twenty-four of the 52 sera showed tube-agglutination titers greater than 1: 40; 35 showed rapid-macroscopic titers greater than 1: 40; and 33 showed agglutinin-blocking properties. It was of particular interest that nine sera which had negative or diagnostically insignificant titers by the tube-agglutination test possessed considerable agglutinin-blocking properties as well as high rapid-macroscopic titers. These results are shown in Table 1.

These results indicate that a significant number of sera from animals in bovine herds where brucellosis is clinically suspected may show negative or very low tube-agglutination titers while possessing agglutinin-blocking properties to a considerable degree. Furthermore, such sera have demonstrated high rapid-macroscopic titers. In this study, no sera were encountered which showed agglutinin-blocking titers, or "incomplete antibodies," which could not be detected by the rapid-macroscopic test. This apparent advantage of the rapid-macroscopic test over the tube-agglutination test would seem to be of practical importance. Further studies are being made to account for the detection of "incomplete antibody" by the rapid-macroscopic test.

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Water Absorption from the Atmosphere by Plants Growing in Dry Soil[1]

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The lower mountain slopes of southern California are blanketed by a cover consisting largely of brush. In some areas, however, Coulter pine (*Pinus Coulteri*) makes up an essential part of this cover. Both the brush species and the pine have one striking common characteristic, an ability to survive long periods of drought on shallow soils which are often at the permanent wilting

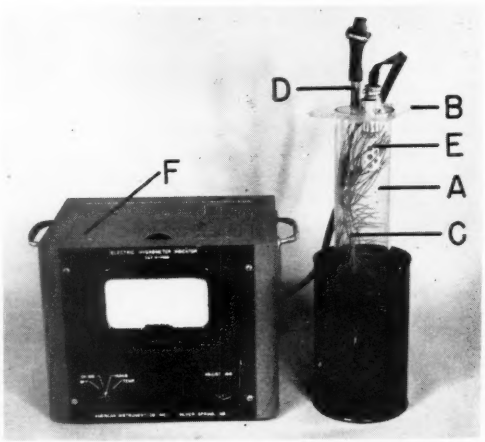

FIG. 1. Apparatus for measuring "negative" transpiration. A, chamber. B, chamber cover. C, Coulter pine seedling. D, brass pipe. E, Amico-Dunmore unit for temperature-humidity sensing. F, microammeter.

point for several months during the late summer. Unpublished lysimeter studies on the San Dimas Experimental Forest in southern California indicate that these plants can survive even on soils below the permanent wilting point as determined by the method of Briggs and Shantz (*1*). Fowells (*2*) worked with another species of pine, *Pinus ponderosa*, and reported that it also survived

[1] This work was carried out as a cooperative project between the California Forest and Range Experiment Station, which is maintained by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California at Berkeley, and the California Institute of Technology, Pasadena, California.

TABLE 1

CHANGE IN THE RELATIVE HUMIDITY WITHIN A TEST CHAMBER AS A RESULT OF WATER ABSORPTION AND WATER LOSS BY THE AERIAL PART OF THE PLANT

Sample number		Relative humidity after different elapsed times (hr)									Calculated absorption force (to the nearest 10 atm)
		0	1	2	3	6	9	24	48	96	
Test plant	A-1	98	94	91	91	90*	..	96	98	98	140
	2	97	88	89	87	86*	90	91	..	..	200
	3	99	88	85	84*	..	..	93	96	97	230
	4	98	96	89	88*	88	89	95	97	98	170
	5	85*	86	85	85	85	85	93	96	98	...
Test plant	B-1	98	96	95*	95	95	95	96	96	96	70
	2	99	97	92	90	89*	90	92	94	97	150
	3	98	96	92	89*	89	89	90	96	98	150
	4	98	97	95*	95	96	95	98	98	98	70
	5	90	90	88*	88	89	90	92	95	97	160
Control plant	C-1	98*	99	98	98	98	98	98	98	98	0
	2	98*	98	98	99	99	99	99	99	99	0
	3	98*	98	98	98	99	98	99	98	98	0
Control plant	D-1	98*	98	98	98	98	98	98	98	98	0
	2	98*	98	98	98	98	98	98	98	98	0
	3	98*	98	98	98	98	98	98	98	98	0
Empty Chamber	E-1	98*	98	98	98	98	98	98	98	98	0
	2	98*	99	99	98	98	98	98	98	98	0
	3	98*	98	98	98	98	98	98	98	98	0

* Lowest value reached for each experimental run.

on soils below the permanent wilting point. This ability to survive on soils so dry that some plants die is yet to be explained.

Several possible explanations worthy of investigation come to mind. It was decided, however, to consider only one at this time, the possibility that aerial portions of these plants take up water from the atmosphere, particularly at night when there is an appreciable increase in the relative humidity of the air.

This paper is a report on (1) the occurrence of such a water uptake from the atmosphere by Coulter pine seedlings and (2) a simple method of measurement.

The data here presented are too limited to permit an evaluation of the practical importance to the plant of such a phenomenon. However, the authors do feel that the method of measurement is direct, simple, and worth reporting, since its use makes possible the study of an interesting and perhaps critical factor in plant survival in the dry regions of the world.

Transpiration is water loss to the air from the aerial parts of the plant and may be through either the stomata, cuticle, or lenticles. Therefore we have considered water uptake from the air as a reversal of normal transpiration, whether it be stomatal, cuticular, or lenticular, and we shall for convenience refer in this paper to this phenomenon as "negative" transpiration.

Basically, the method of measurement consisted of inserting the part of the plant to be measured into a closed chamber in which the initial relative humidity could be readily adjusted and then recording changes in the relative humidity within the chamber by means of a humidity-sensing unit.

The assembled apparatus is shown in Fig. 1. The chamber (A) was made from Plexiglas tubing of 2-in. diam. It was closed at one end by a piece of ¼-in. Plexiglas (B), and at the other end by a split, one-hole rubber stopper. The stopper was slipped around the stem of the plant, in this instance a Coulter pine seedling (C), and sealed with Lubri-seal; the roots and soil sealed in their container were undisturbed. Then the stopper and plant were fitted into the chamber and enough mercury poured in through the opening in the Plexiglas cover—in which later the humidity-sensing unit (E) was threaded—to cover the stopper with a ¼-in. layer; this furnished an airtight seal. The relative humidity was adjusted by the operator's blowing into the chamber through the brass tube (D), which had been threaded through the Plexiglas cover. In preliminary runs, CO_2 was removed from the water-saturated air stream before it entered the chamber, but when it was found that this did not affect the results it was discontinued. Determination of relative humidities was made with an Amineo-Dunmore unit for temperature-humidity sensing and accompanying microammeter (F). Relative humidity and temperature could be determined with an accuracy of $\pm 0.5\%$ and $\pm 1.0°$ C respectively, but humidity readings for values above 98% were found to be unreliable. These values represent anything from 98% to 100% relative humidity and must be considered accordingly.

Test material consisted of two 2-yr-old Coulter pine seedlings which had been growing in containers, sealed from the atmosphere with grafting wax, to which no water had been added for more than 10 months. During this time each container had been partially immersed in a tank of water in order to maintain constant temperatures in the soil mass, and the whole was shaded from direct sunlight by a sheet of canvas. The soil in both containers, when examined at the end of the experiment reported below, was at the wilting point as determined by the method of Briggs and Shantz (*1*).

The control was of two kinds. One consisted of two 2-yr-old Coulter pine seedlings which had been well watered throughout their entire lives; the other consisted of an empty chamber.

The apparatus was checked before each experimental run for leaks and drifts in the relative humidity readings with time. When drifting did occur, more moist air was added to the empty chamber until readings remained constant for 6 hr; not until then was the chamber used.

Before each experimental run, both the test plants and the control plants were placed in front of a fan for 48 hr in order to assure a water deficit in the aerial part of the plant. Preliminary runs had shown that the same effect could be obtained by placing the plants in full sun for a week or more. The 48-hr exposure in front of the fan merely made possible a larger number of runs in the same period of time.

All experiments were carried out in diffused light at room temperatures which remained relatively constant (24.5° ± 0.7° C).

Five experimental runs were made with each test plant (A 1–5 and B 1–5 in Table 1). After each test plant a control plant was run; only six of these are shown (C 1–3 and D 1–3 in Table 1). Before each experimental run a blank run was made in which the chamber was empty; only three of these are shown (E 1–3, Table 1).

Results in Table 1 indicate that water was removed from the air by the aerial parts of the plants growing at the wilting point, but not by the control plants growing in well-watered soil. As a result of this negative transpiration, relative humidities as low as 84% were obtained in the test chamber.

Data in Table 1 also show that the test plants, which at first display "negative" transpiration, later display normal transpiration after a 24-hr period in the test chamber, even though the rate is extremely slow. This could be explained on the basis of a slow water uptake by the roots when in soil at the wilting point. When first placed in the chamber, the aerial portions of the plant remove water from the air until the vapor pressure of the water at the leaf surface is equal to the vapor pressure of the water in the surrounding chamber. As water is gradually removed from the soil by the roots, it passes through the conducting system into the leaf; then vapor pressure of the water in the leaf increases and water loss to the atmosphere begins, showing as normal transpiration.

Five-year averages of the relative humidity in the San Gabriel mountains of southern California during the period from July to October show that values of 90% or more were recorded an average of 18 days per month with an average duration of 8 hr, at 1,500 ft and 8 days per month with an average duration of 7 hr, at 2,800 ft. These are conservative figures (probably low), since they were taken in a standard shelter 4 ft above the ground in a cleared area, and not at the leaf surface where radiation effects are operative. Nevertheless, they do show that relative humidities are such during the summer that negative transpiration can occur under field conditions.

Calculations of the maximum absorption forces (suction pressures or diffusion pressure deficits) attained in each experimental run are shown in the last column in Table 1. Relative humidities of 98% and above are considered as 100%, because of the inaccuracy of the instrument in this range; absorption forces are consequently considered as 0 under such conditions. Calculations were based upon the relation existing between vapor pressure, relative humidity, and osmotic concentration of a salt solution contained in a closed vessel. At a specific temperature such a salt solution has a specific vapor pressure and the air above it a specific relative humidity. If air of a higher or lower relative humidity is introduced into the closed vessel, the original relative humidity is again attained after a short period of time; this will continue to happen as long as the concentration of the salt solution is not appreciably changed by the gain or loss of water in the form of vapor. Therefore, when the relative humidity above a solution is known, the osmotic concentration of the solution, which is identical to the absorption force for water, can be calculated. For example, in one of the experimental runs cited in Table 1, water at the leaf surface was in equilibrium with an atmosphere of 84% relative humidity. This relative humidity would also exist over a salt solution with an osmotic concentration of about 230 atm; hence, the absorption force developed at the leaf surface was considered to be 230 atm.

Since such large forces are developed, one would not expect leaves with large thin-walled cells, as on the sunflower plant, to display negative transpiration of a measurable magnitude, or to develop high absorption forces in the leaves. On the other hand, leaves of many of the desert and Mediterranean type plants are mechanically much stronger, and in them negative transpiration and high absorption forces under drought conditions may be expected. Even if this is found to be generally true, much more experimental work must be carried out to determine whether this absorption of water in itself is an important survival factor or whether it is merely a phenomenon that can occur in plant tissues rigid enough to resist collapse when desiccated.

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Disruption of Mitosis by Desiccated Thyroid Tissue

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It has been reported that numerous substances, notably colchicine (*1*), acenaphthene (*4*), salts of heavy elements (*5*), and ribose nucleic acid (*3*) disrupt onion root mitosis in producing polyploidy, c-mitosis, nondisjunction, and chromatin bridges. Except for colchicine and ribose nucleic acid, the substances used were mainly those not found in living organisms. With this in mind,

several preparations of organic substances that normally occur in mammals were used, namely, acetyl choline, adrenalin, insulin, parathyroid powder, dried thyroid tissue, and histamine. These substances were made up in concentrations from 0.001 g to 10 g/100 ml of H_2O. Onion roots were treated with these concentrations for 4–72 hr, and smears were made with aceto-brilliant cresyl blue following the procedure of Stewart and Schertiger (*6*).

TABLE 1

EFFECT OF VARIOUS CONCENTRATIONS OF THYROID POWDER ON ONION ROOT MITOSIS

Plant No.	Thyroid powder in g/100 ml of H_2O	Length of treatments in hr	Predominant types of abnormality
20	0.130*	48	nondisjunction
44	0.500	4, 8, 27, 72	nondisjunction c-mitosis chromatin bridges
59	0.700	24, 31	c-mitosis chromatin bridges
62 and 63	1.00	23, 41, 48	c-mitosis chromatin bridges shattered nuclei
64	1.00	24, 48	c-mitosis
65	1.00	24	c-mitosis
66	1.00	24	c-mitosis

* Concentrations below 0.130 g gave normal mitotic figures.

Thyroid powder (control number H17204 Armour and Company, Chicago) was the only one that produced abnormal mitotic figures in onion root cells. Of the 18 plants treated with thyroid powder, eight showed very definite abnormalities (see Table 1); root smears from four showed some mitotic irregularities; in three plants there were no abnormalities; and in three others the thyroid powder concentrations were below the threshold, 0.130 g/100 ml H_2O. The most common abnormality at higher concentrations was c-mitosis (Fig. 1), whereas at lower concentrations, below 0.7 g/100 ml H_2O, the most frequent abnormality was chromatin bridge formation (Fig. 2). The presence of c-mitosis indicates that a metaphase block and incomplete splitting of the chromosomes had occurred. Note in Fig. 1 that the chromosomes are in an extremely contracted state and that the partially split chromosomes are still attached at the centromere. Mitosis seems to have been stopped at this stage. The chromosomes resemble those found in the process of meiosis. The chromatin bridges, we believe, are due to the failure of chromosomes to separate completely. A chromosome may split partially so that a separate centromere is present in each product of the split chromosome, although the rest of the chromosome has not split. During anaphase these unsplit ends are, therefore, stretched between opposite poles. There is also a possibility that the bridges may result from somatic crossing over. The thyroid powder may affect the spindle, for several cells showing nondisjunction have appeared in smears.

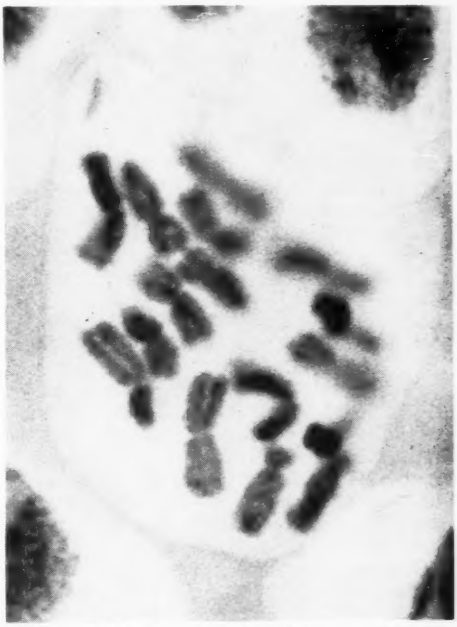

FIG. 1. C-Mitosis produced in onion root cell by treatment with 1 g thyroid powder/100 ml H_2O for 24 hr. Magnification × 2600.

Since thyroxin is a well-known constituent of thyroid tissue, it was suspected of being the causative agent of mitotic abnormalities. Concentrations of thyroxin (sodium salt) ranging from 1 mg to 40 mg/100 ml of buffer pH 7.8 were used. Mitosis in the onion root was normal. Thyroxin as the causative agent can, therefore, be ruled out, since 1 mg of crystalline thyroxin per 100

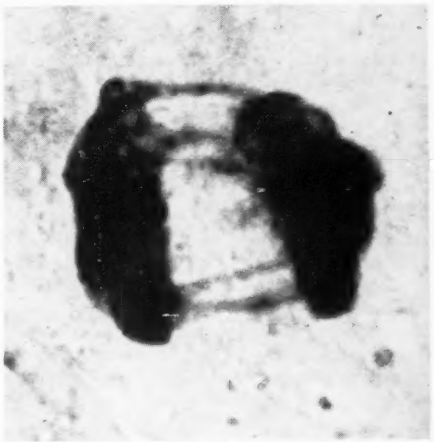

FIG. 2. Chromatin bridges produced in onion root cell by treatment with 0.5 g thyroid powder/100 ml H_2O for 8 hr. Magnification × 2600.

ml of distilled water is over 100 times the concentration of thyroxin found in 1 g of thyroid powder. In doses of 10 mg or higher of thyroxin, root growth ceased, and at a lower concentration growth was slowed down.

Kodani (*3*) has demonstrated that a 2%–4% solution of ribose nucleic acid is the optimum range in which mitotic abnormalities are produced in onion root cells. In solutions of 0.05% and 0.1% of ribose nucleic acid growth was normal. In our laboratory we have found that a 2% solution of desoxyribonucleic acid (Lot No. DN4902, Schwartz Laboratories, New York City) induced mitotic abnormalities in onion root cells. Is there enough ribose nucleic and desoxyribonucleic acids in dry thyroid tissue to account for the abnormalities observed? Davidson and Waymouth (*2*) reported that in dry thyroid tissue from sheep there are 148 mg of nucleic acid P/100 g of tissue. Since P is approximately 10% (more likely 8.5%–9.5%) of nucleic acid molecules there is 0.014 g of nucleic acid/g of thyroid tissue. In 1 g of thyroid/100 ml of water, we then have 0.014% solution of nucleic acids. The concentration of thyroid tissue used in the present tests certainly does not contain enough nucleic acids to account for the abnormalities observed. Evidently there is some unknown factor in the thyroid powder which is responsible for the production of c-mitosis, chromosome bridges, and nondisjunction. The normal mitosis is upset. How this is done is unknown. This factor may either enter the cell or act upon another substance outside the cell, which in turn enters and affects the metabolism of mitosis. Since solutions of the thyroid powder that have been made up and placed in the refrigerator for 24–48 hr before use were usually more potent in producing abnormalities than fresh solutions, a decomposition product may be the causative agent.

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A Laboratory Lyophil Apparatus[1]

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During the course of work in the Gates and Crellin Laboratories, a need arose for a lyophil apparatus capable of handling liter quantities of solution. The apparatus of Campbell and Pressman (*1*) was inadequate, since the limiting capacity of this apparatus was about 400 ml of solution. Furthermore, the apparatus could be operated only intermittently, since several hours were required between lyophilizing operations for de-icing of the condenser surface. As a result, a modified apparatus was developed which obviated these difficulties and which had the additional advantages of low cost and ease of construction. This apparatus is shown in Fig. 1.

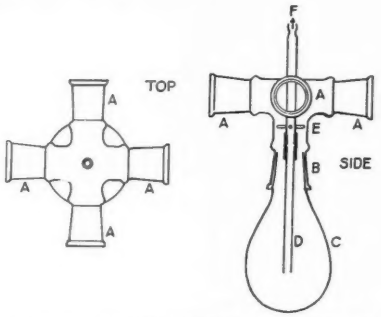

Fig. 1. Lyophil apparatus. A, ports, ST 34/45, for flasks; B, ST 34/45, for receiver flask; C, receiver constructed from 800-ml Kjeldahl flask; D, removable tube connected to center tube with rubber tubing; E, three glass pin supports arranged symmetrically on center tube; F, to vacuum.

The apparatus consists essentially of five female standard taper 34/45 joints. Four of the joints, which are arranged at right angles, serve as ports for the insertion of lyophil flasks. The flasks were constructed from male 34/45 joints and Kjeldahl flasks as described previously (*1*). The joints are arranged as compactly as possible in order to shorten the path of water vapor from the lyophil flask to the receiver; however, apparatus with joints having arms of 2 in. to 3 in. still operate effectively. The fifth joint accommodates the receiver for condensing moisture. The receiver is simply another lyophil flask constructed from an 800-ml Kjeldahl flask and is replaced periodically during operation of the apparatus.

TABLE 1

Operation time (hr)	Percent total water collected
0.9	21.1
2.0	44.5
3.2	64.4
4.3	80.2
5.9	97.2

The operation of the apparatus was similar to that of Campbell and Pressman (*1*). The four flasks were filled with solution and frozen by turning in a bath of methyl cellosolve and dry ice. The flasks were attached to the apparatus after lubrication of the joints, the receiver was put in place, and the apparatus was moved downward until the receiver was immersed to within a few inches of the joint in a dry ice-methyl cellosolve bath. The cooling mixture was conveniently contained in a 1-gal wide-mouthed Dewar flask. The system was then evacuated with an efficient vacuum pump (a Hyvac was satisfactory). In order to replace the receiver, air could be admitted into the system through an auxiliary manifold system. The

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limiting capacity of the 800-ml receiver is about 300 g of water, since this is the maximum amount of water that can be frozen in the flask safely without breakage during subsequent de-icing. De-icing was conveniently performed by allowing the flask to warm slowly in air.

TABLE 2

Operation time (hr)	Water collected (ml)
3.5	325
5.5	700
11	1015
27	1040 (complete)

The efficiency of the apparatus may be judged from the data in Table 1. Approximately 6 hr was required to remove 200 ml of water distributed equally between four 400-ml flasks. The time of sublimation is somewhat slower than that possible with the apparatus of Campbell and Pressman (*1*), as might be expected from the shorter path from the ice surface to condensing surface in the latter apparatus. The effectiveness of the present apparatus with large volumes of solution is evident from the results in a typical run (Table 2) in which 1050 ml of a dilute solution of blood group A substance was distributed among four 800-ml flasks. The lyophilizing was essentially complete after 27 hr, the apparatus being in continuous operation during this time except for receiver changes. Care must be taken if melting of the material in the lyophil flask is to be avoided to make the final receiver exchange when sufficient ice remains in the lyophil flasks to keep the material frozen. This precaution may be of importance in case the material being lyophilized is denatured readily.

The author is indebted to D. H. Campbell and E. L. Bennett for discussion concerning the operation and construction of this apparatus.

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Pollination of *Asarum canadense* L.

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There has been some question whether *Asarum canadense* L. is self-pollinated or whether it is cross-pollinated by insects. Guides to the wild flowers of the northeastern states, even some of those most recently published, state that *Asarum canadense* L. is pollinated by small insects found among dead leaves on the forest floor. At least one species of *Asarum* is known, however, not to be so pollinated. Kugler (*1*) was led by his experiments to conclude that insects in no way aided the pollination of *Asarum europaeum* L. He further showed that the stigma matured first, but it was still receptive to pollen at the time the anthers of the blossoms matured. He thought that *A. europaeum* L. could be and probably was self-pollinated.

To ascertain the type of pollination occurring in *A. canadense* L. the following method was employed. The anthers and filaments were removed from the blossoms, some of which were left uncovered, and some covered with wax paper bags. Still other blossoms, with the flower parts intact, were covered with wax paper bags before the stamens matured. Care was taken to see that no insects were present in the flowers at the time of covering.

Thirty-seven of the 50 plants, whose blossoms had been covered and the flower parts left intact, were observed a few weeks later. Of these 37, 26 had produced seeds. These could be distinguished readily by the greatly enlarged or inflated ovary. When they were opened, sound seeds were found. Four of these 37 plants had not produced seeds. Their blossoms were not withered or dried. Seven other plants had blossoms which had withered and turned brown, showing no sign of seed development.

Thirty of the 50 plants with covered blossoms and with stamens removed were observed. All of these were abscised. No trace of any blossoms was found in the 50 specimens from which stamens had been removed and which were left uncovered among the other intact plants. In the flowers from which the stamens were removed, or where the stamens for some reason had not developed, the pistils withered and died.

The few insects seen to visit the flowers during this experiment were fulgorids, aphids, and one ant.

Since no plants with stamens removed produced seeds, whether the flowers were covered or uncovered, and since the majority of those with flowers intact did produce seeds, even when enclosed in bags, it seems reasonable to conclude that the plants are normally self-pollinated and that cross-pollination occurs rarely if at all. The plants in this group that did not produce seeds had evidently become injured while being tied up.

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Comments and Communications

Catalytic Effect of the Chromic Ion in the Barker Method for Protein-bound Iodine Determination[1]

In attempting to use S. B. Barker's method (*J. biol. Chem.*, 1948, **173**, 715) for the determination of protein-bound iodine, we at first obtained unsatisfactory results because of high reagent blanks. All batches of chromic acid tested appeared to be contaminated with iodine. With any given set of reagents the blank varied considerably from day to day. This suggested that the blank reading did not represent iodine alone, but was in part due to the effect of some other substance. Since traces of chromic ion may be carried over into the trap during distillation, the ability of this ion to catalyze the reaction between ceric ammonium sulfate and arsenious acid was investigated. The catalytic effect of the chromic ion proved to be quite sufficient to account for the high and variable blanks.

We had been using the quantities of reagents recommended by Barker for the catalytic reaction, except that we used one and one-half times as much sodium chloride. However, with an Evelyn colorimeter a final volume of 11.5 cc was more convenient than the 5.9-cc volume originally described. Our final *concentrations* of sulfuric acid, arsenious acid, and ceric ammonium sulfate were thus about one-half those used by Barker. Although these lower concentrations were entirely satisfactory for pure solutions of iodide, it seemed possible that the lower acidity might favor the catalytic effect of the chromic ion. Accordingly, the acid concentration was progressively increased. With each increase the catalytic action of the chromic ion waned, while that of iodide was but slightly affected. Thus, with sulfuric acid concentrations of 0.20 *N*, 0.44 *N*, 1.07 *N*, and 2.33 *N*, the catalytic effect of 5.8 μg of Cr^{+++} was equivalent to that of 0.0202, 0.0115, 0.0038, and 0.0008 μg of iodide respectively. An increase in the sodium chloride concentration (from 32 mg % to 152 mg %) enhanced the catalytic effect of iodide but not that of the chromic ion.

When the revised procedure for the catalytic determination was applied to the whole Barker method, the results were markedly improved. With an acid concentration of 0.23 *N*, the mean reagent blanks in 11 analyses had been 0.109 μg of apparent iodide, with a standard deviation of ±0.017 μg, and the mean recovery of 0.1 μg of iodide added before digestion in 21 analyses had been 89% with a standard deviation ±21%. When the acid concentration was increased to 1.07 *N*, the mean reagent blank in 8 analyses was 0.095 μg, with a standard deviation of ± 0.005 μg, and the mean recovery of 0.1 μg of added iodide in 26 analyses was 97%, with a standard deviation of ±10%. When the acid concentration was still further increased to 2.33 *N*, the mean recovery of 0.1 μg of added iodide in 34 analyses was 102%, with a standard deviation of ±7%. The mean blank values are not strictly comparable, since the batches of reagents and the "carrier" protein differed in each series, but the striking reduction in variability of both blanks and recoveries is evident from the much smaller standard deviations obtained with increased acidity.

For convenience, the increased amounts of sulfuric acid[2] and sodium chloride may be added to the arsenious acid reducing solution when this reagent is being prepared. The quantity of arsenious acid itself has not been changed, since in a few experiments doubling its concentration did not significantly affect the results. None of the other reagents has been changed.

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[1] This work was aided in part by a grant from the William W. Wellington Memorial Research Fund.

[2] The arsenious acid solution should be carefully cooled during the addition of the sulfuric acid; if this is not done, the arsenious acid may crystallize out of solution during the next 24 hr.

[3] Research fellow in pharmacology July 1, 1948 to January 1, 1949, Milton Fellow, January 1, 1949 to July 1, 1949.

The Role of Lemmings at Point Barrow, Alaska

Lemmings (*Dicrostonyx rubricatus* Richardson and *Lemmus alascensis* Merriam) are the most numerous mammals in the vicinity of Point Barrow on the coast of the Arctic Sea and without doubt the most significant from the point of view of biological role. In appearance they suggest large, squat mice with abbreviated tails, the *Dicrostonyx* being richly patterned in grays and browns, the *Lemmus* being rather uniformly dark tawny. Although their numbers fluctuate markedly, they are generally the basic food for such carnivorous animals as the snowy owl, pomarine jaeger, and arctic fox.

Field work in 1949[1] confirmed brief observations in 1948 indicating that lemmings play a far more important role in the life of the tundra than is generally realized. From the regurgitated pellets of the snowy owl consisting of lemming fur and bones, larvae of the common midge of this region, the chironomid or tendipedid, *Spaniotoma*, and springtails or Collembola were taken in 1948 (Weber, N. A. *Ent. News*, 1949, **60**, 118).

The most numerous and significant arthropods of the tundra were found to be various species of true flies or Diptera, including the *Spaniotoma*, and springtails and mites (Weber, N. A. *Ent. News*, 1948, **59**, 253; 1949, **60**, 118). Many of these form important links in the food chain between the tundra vegetation and the largest animals. They are basic in the sense that they feed directly upon the vegetation or on animal remains and in turn are fed upon by larger animals.

By the spring of 1949 lemmings had built up to large populations and, as the snow cover disappeared in June,

[1] Sponsored by the Office of Naval Research and the Arctic Institute of North America.

great numbers of their fluffy winter nests and the runways leading to them were left exposed. Not hibernating, they had consumed most of the vegetation in many areas and left the surface littered with shredded grasses and sedges. During June many lemmings were found dead, and it is possible that exhaustion of the food supply and starvation had been an automatic brake on their increase.

These fluffy nests, 15 cm to 30 cm in diam, with their runways created ideal environments for the three major types of arthropods and large numbers were consistently found in them. From one nest about 1,100 springtails, 100 mites, and 40 *Spaniotoma* larvae were taken. From another nest 1,670 *Spaniotoma* larvae, 545 mites, and 2,830 springtails were counted. Other invertebrates such as oligochaete worms and staphylinid beetles are also found here regularly. The surrounding tundra by contrast contained far fewer numbers of these, and it is obvious that this part of the arthropod fauna fluctuates with the numbers of lemmings and is largely dependent on them. When the lemmings increase too greatly they consume plants faster than they can grow in this cold climate and so starve themselves. This may lead to a general decrease in the three major arthropod groups, followed by a luxuriant development of the vegetation, and thus prepare the basis for another cycle. A more comprehensive report will be given elsewhere.

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Temperature and Man

Associating the Dark Ages with a receding polar ice cap and a warmer climate (Clarence A. Mills, *Science*, 1949, **110**, 267) leads to some difficulty, if the idea is examined in the light of world history. *World* is used in a broad enough sense to include area outside that in which Western civilization has developed. One of the more advanced periods in Chinese history, the Tang dynasty, coincided with the Dark Ages. The culture of the Indian civilizations of Central and South America of the same period is worthy of respect. Even if we confine our consideration to Europe and North Africa, we notice that while the regression of the polar ice cap was creating optimum temperatures for human activity in the Nordic regions, purportedly stimulating the inhabitants to exploration and settlement, the Islamic world was expanding with considerable energy in the unseasonably warm areas of the Mediterranean.

It is indicated in the paper under discussion that the greater proportion of the Presidents of the United States of America and the persons included in Who's Who were conceived in the more invigorating seasons of the year, yet nothing is said of the seasonal distribution of conceptions of the populace as a whole.

If human activity directed towards the building and maintenance of civilizations could be soundly correlated with environmental temperature, it would still be necessary to recognize indirect effects of temperature upon man such as the effect of temperature upon his natural enemies, particularly microorganisms; the necessity for more forethought and providence where he is faced with a long season in which plant life is nonproductive and during which he must protect himself from the rigors of the climate.

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. . . Among other amazing statements, Dr. Mills says that "college students, given the standard aptitude or intelligence tests at Cincinnati latitudes across the country, achieve ratings only 60 percent as high in summer heat as in winter cold." This would mean that psychological tests are quite worthless for measuring intelligence at Cincinnati, but can be used with reasonable reliability for determining temperatures. If that statement were true, most people rated in winter as of average intelligence would rate as feeble-minded in summer, and some of them would be classified as imbeciles. I don't think that any competent psychologist—even in the hottest Cincinnati summer—would agree with Dr. Mills on this point.

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News and Notes

American Chemical Society's 117th National Meeting—Philadelphia and Detroit Sessions

Walter J. Murphy

American Chemical Society

Philadelphia. The discovery that the antibiotic aureomycin is a potent growth accelerator, producing effects beyond those obtainable with any known vitamin, was one of the outstanding chemical contributions in the fields of nutrition and health announced at the Philadelphia meeting of the ACS.

This, the second of three sessions into which the meeting was divided, was held April 9–13, with 3,900 chemists and chemical engineers participating. The first session was conducted in Houston, March 26–30 (*Science*, April 21, p. 449).

Selection of Charles A. Kraus, professor emeritus of chemistry at Brown University and a former ACS president, as winner of the Priestley Medal, highest honor in American chemistry, was announced by Ernest H. Volwiler, president, at a general assembly on April 10. Dr. Kraus will receive the medal at the society's fall meeting in Chicago.

Three awards were presented at the general assembly. A. J. Haagen-Smit, of the California Institute of Technology, received the Fritzsche Award of $1,000 and a gold medal for his work on essential oils. The Borden Award in the Chemistry of Milk, consisting of $1,000 and a gold medal, went to George A. Richardson, of Oregon State College. Britton Chance, director of the Eldridge Reeves Johnson Foundation for Medical Physics of the University of Pennsylvania, received the $1,000 Paul-Lewis Laboratories Award in Enzyme Chemistry, which also includes a gold medal.

Prof. Chance, in his award address, described an apparatus he has developed for studying enzymatic catalysis. A thousand times more powerful than any previously available device, the new apparatus has enabled him to measure reactions occurring within 2 msec, and has thus opened the way to a wealth of knowledge about basic life processes.

The hitherto unsuspected nutritional powers of aureomycin, which may be of great value in extending the world's meat supply and decreasing its production costs, were reported by E. L. R. Stokstad and T. H. Jukes of the Lederle Laboratories Division, American Cyanamid Company. Minute quantities of the drug mixed with feed increased the rate of growth of pigs by as much as 50% and had a similar effect on chicks and turkey poults. Clinical investigations of the possibility that aureomycin may aid the growth of malnourished and undersized children are now under way.

Out of a symposium on the effect of steroids on mammalian metabolism came the theory that the effectiveness of cortisone, sex hormones, and other steroids in combating rheumatoid arthritis may be increased by regulating the nutritional level of patients. This theory will be tested clinically by St. Luke's Hospital, New York City, this summer, in a broad study of the entire relationship of nutrition and metabolism to steroidal therapy, it was announced by Symposium Chairman Anthony A. Albanese of St. Luke's Nutritional Research Laboratory.

A new type of weapon against virus diseases may result from research described by Seymour S. Cohen, of the Children's Hospital of Philadelphia and University of Pennsylvania School of Medicine. Dr. Cohen found that multiplication of viruses can be halted in the test tube by introduction of 5-methyl tryptophan, a substance similar to the amino acid tryptophan. It may eventually be possible to develop compounds for the treatment of virus announced by Symposium Chairman Anthony A. Albanese of St. Luke's Nutritional Research Laboratory.

Another important contribution to virus knowledge was reported by H. T. Epstein and Max A. Lauffer of the University of Pittsburgh. They offered convincing evidence that the virus particles seen through the electron microscope, and analyzed by physical and chemical techniques, are actually the bearers of virus infection. Southern bean mosaic virus was used in the research, which employed a new technique based on sedimentation velocities.

Development of a drug opening up a new approach to the treatment of peptic ulcer was announced by John W. Cusic and Richard A. Robinson of G. D. Searle and Company. The compound, ß-diethylaminoethylxanthene-9-carboxylate methobromide, relaxes the smooth muscle of the stomach, thereby reducing spasm, and also inhibits the nerve impulses causing acid secretion by the stomach. This is the first single compound to meet both major requirements of an effective ulcer treatment.

A series of new synthetic chemicals which, in laboratory tests, equal the antituberculosis potency of streptomycin was described by Jack Bernstein and co-workers, of E. R. Squibb and Sons Research Laboratories. The compounds, which can be taken orally, are members of the class known as thiosemicarbazones, first reported in 1946 by Gerhard Domagk and three other German chemists. The Squibb researchers have synthesized more than 100 thiosemicarbazones, several of which have proved highly effective on mice.

Utilization of radioactive tracer techniques has made it possible for the first time to follow all parts of a cancer-forming chemical through body processes, John H. Weisburger, of the National Cancer Institute, announced. Describing research on the carcinogen 2-acetylaminofluorene, he said the achievement may permit identification of the specific part of a compound which causes cancer.

A vast untapped food reserve in Central America, provided by common foods and a variety of other edible plants, has been uncovered in a three-year survey conducted by the Nutritional Biochemistry Laboratories of the Massachusetts Institute of Technology, Hazel E. Munsell and associates reported.

Symposia on the metabolic role of vitamin B_{12} and its place in the feeding of farm animals, newer developments in fungicides, and 1950 placement problems were other high lights of the program, which also included the first symposium ever held on the application of chemistry to archaeology.

Detroit. Research progress in fields ranging from chemical warfare to the measurement of bone density in living persons was reported at the Detroit session. More than 2,750 chemists and chemical engineers participated in this final session of the divided meeting, bringing the total attendance for the Houston, Philadelphia, and Detroit gatherings to 8,456.

Nation-wide interest was aroused by Anthony C. McAuliffe's revelation that the Army Chemical Corps, of which he is chief, is developing weapons that can shatter a foe's will to fight without wrecking his economy. Gen. McAuliffe, who addressed a general assembly in the Detroit Music Hall on April 17, made it clear that the new weapons would never be used by the U. S. save for purposes of retaliation, but he stressed the need for continued research along this line in the interests of defense. Pointing out that the Soviet Union is known to be exploiting many German experts on chemical warfare, he said it must be assumed "that we are not the sole possessors of the offensive and defensive secrets of the new nerve gases."

The $1,000 American Chemical Society Award in Pure Chemistry was given to Verner Schomaker, of the California Institute of Technology, at the general assembly. This award is financed by Alpha Chi Sigma. The Francis P. Garvan Medal, honoring women in chemistry, was presented to Pauline Beery Mack, director of the Ellen H. Richards Institute and professor of household chemistry at the Pennsylvania State College. Dr. Mack told, in her medal address, of an ingenious technique for measuring bone density, which may lead to the development of a sturdier human race. Fewer bow legs, stronger skeletons, and better health at all age levels can be assured through use of this technique, which employs an electronic device to analyze x-rays.

A report on the chemistry of berkelium, element 97, was presented by S. G. Thompson and Glenn T. Seaborg of the University of California. The new element has been found to be chemically related to terbium, just as had been predicted from the fact that berkelium occupies a position in the actinide series analogous to that held by terbium in the lanthanide series.

Several advances in the purification of water were reported. Completely pure drinking water, free from the unpleasant chlorine taste as well as from germs, can be prepared at low cost with the aid of common sand or clay, Ernst Hauser, of the Massachusetts Institute of Technology and the Worcester Polytechnic Institute, said. He asserted that sand or clay could serve as a source of atomic oxygen which would "act like a strong poison on germs" and prevent the putrefaction of organic matter.

An electrolytic process for effecting coagulation and removal of impurities was described by Paul G. Stephan and A. C. Brumley of Alhydro, Inc., Baltimore. Stainless steel equipment and some radically new ideas in design have made continuous operation of such a process feasible for the first time.

F. X. McGarvey and Joseph Thompson of the Rohm and Haas Company, Philadelphia, announced a new ion exchange resin which softens hard water efficiently and cheaply. New triple-action detergents which remove dirt, bacteria, and unpleasant odors were reported by Joseph B. Niederl, of New York University; Martin E. McGreal, of St. John's University, and William F. Hart, of Lafayette College. They said the compounds, which are morpholinium alkyl sulfates, are "the most nearly ideal cleansers" so far developed.

An entirely new concept of the role of carbon black in rubber processing was announced by R. S. Stearns and B. L. Johnson of the Firestone Tire and Rubber Company. Their theory explains the toughening effect of carbon black on rubber in chemical rather than physical terms, thus upsetting the view held by most rubber technologists in recent years. The submicroscopic particles of carbon black added to rubber in the manufacture of tires and other rubber products are not inert, as formerly supposed, but have reactive carbon atoms on their surfaces similar to the reactive carbon atoms of rubber. This enables the carbon black to take part in the vulcanization reaction and combine chemically with the rubber.

Clearer radio reception in moving automobiles, elimination of annoying shocks from touching charged objects, and fewer industrial accidents caused by sparks were predicted by L. R. Sperberg and associates, of the Phipps Petroleum Company. These advances will result from new rubber compositions which will conduct electricity.

Gordon K. Moe, associate professor of pharmacology at the University of Michigan Medical School, has been appointed professor of physiology and head of the department at New York State University College of Medicine at Syracuse, effective July 1.

R. G. Grenell, who has been a senior fellow of the U. S. Public Health Service in the Department of Biophysics at Johns Hopkins University, has been appointed research associate and director of the Research Laboratories of the Department of Psychiatry, University of Maryland School of Medicine.

Robert E. Marshak, theoretical physicist at the University of Rochester, has been appointed chairman of the Physics Department of the University, to succeed **George B. Collins,** who resigned April 1 to take charge of large scale accelerator work at Brookhaven National Laboratory. Dr. Marshak is known for his work in the development of the theory of light and heavy types of mesons. He will serve as visiting professor of physics at Columbia University during the summer session.

I. C. Gunsalus and **S. E. Luria,** bacteriologists at the University of Indiana, will join the staff of the University of Illinois Department of

Bacteriology in September. Dr. Gunsalus will become a professor in the department, and Dr. Luria a research professor.

Franz Schrader, head of Columbia University's Department of Zoology, has been appointed Da Costa Professor of Zoology at the university. This chair was named in honor of Charles M. Da Costa, who gave the funds to establish the Department of Zoology.

Barbara K. Campbell, lecturer in chemistry at Indiana University, was recently elected national president of Sigma Delta Epsilon, the honorary organization for women engaged in research in the physical, mathematical, biological, and medical sciences. Dr. Campbell has collaborated for many years with her husband, K. N. Campbell of the University of Notre Dame, in research on antimalarials, the chemotherapy of cancer, and synthetic drugs.

Deane B. Judd, of the Photometry and Colorimetry Section of the National Bureau of Standards, recently received the Department of Commerce Exceptional Service Award for outstanding scientific accomplishment in the fields of colorimetry and color vision. Dr. Judd has been in charge of the bureau's colorimetric work for the past 17 years and developed a mathematical treatment of color blindness which affords an understanding of the relations between normal and color-blind vision.

Hans A. Bethe, Cornell University physicist, has been appointed Walker-Ames Professor of Physics at the University of Washington, Seattle, for the month of July. Dr. Bethe will conduct two graduate seminars on phases of recent nuclear research.

Visitors to U. S.

Recent visitors at the National Bureau of Standards were **P. J. Daglish,** manager of the Standards and Specifications Section, English Electric Company, Ltd., Rugby, England; **John D. Hastings,** of the Research Laboratory of the Socfin Plantations, Kuala Lumpur, Malaya; **Karl Neumaier,** chief of the Cartography and Surveying Unit, standardization and testing agency for the government of Austria; and **W. S. Karis,** deputy chief engineer, Post and Telegraph Ministry of Communications, Pakistan, who is now training with the Federal Communications Commission in Washington, on a UN fellowship.

Isamu Nagai, of the National Institute of Health, Tokyo, Japan, and **J. F. A. Sprent,** of the Ontario Research Foundation, Toronto, recently visited the Army Medical Department Research and Graduate School in Washington, D. C.

William J. Bishop, librarian of the Wellcome Historical Medical Library of London, will address the Medical Library Association's 1950 convention, to be held in Boston, June 19–22. Dr. Bishop's subject will be "Medical Libraries and Librarianship in Great Britain."

Grants and Awards

The American Academy of Arts and Sciences has announced the following grants-in-aid from its Permanent Science Fund: *Bodie E. Douglas,* assistant professor of chemistry, Pennsylvania State College, $300 for an investigation of the *trans* effect in coordination compounds; *Loo-keng Hua,* professor of mathematics, Tsing Hua University, and visiting professor, University of Illinois, and *Lowell Schoenfeld,* assistant professor of mathematics, University of Illinois, $300 for preparation of manuscript on the modern analytic theory of numbers; *J. Logan Irvin,* assistant professor of physiological chemistry, Johns Hopkins University School of Medicine, and *Elinor Moore Irvin,* volunteer, $1,000 for a physicochemical study of the interaction of quinoline and acridine derivatives with nucleic acids and nucleoproteins; *John James,* instructor, Department of Sociology, University of Oregon, $1,000 for a comparative study of small group size in the formal and informal organization of an industrial plant; *Michel Macheboeuf,* professor, Institut Pasteur, Paris, $2,000 for a study of lipoproteins; *Giuseppe Moruzzi,* professor of physiology and head of the department, University of Pisa, Italy, $1,500 for an investigation of the mechanism of the cortical arousal reactions; *Irvine H. Page,* director, Research Division, Cleveland Clinic Foundation, $1,500 for a study of the histopathology of vascular tissues by electron microscopy; *John W. Patterson,* assistant professor of anatomy, School of Medicine, Western Reserve University, $2,000 for a study of the role of ascorbic and dehydroascorbic acids in metabolism; *Jay S. Roth,* assistant professor of biochemistry, Bureau of Biological Research, Rutgers University, $400 for a study of the effects of certain carcinogenic agents on the growth rate and respiration of *Tetrahymena geleii; Harlow Shapley,* director, and *Bart J. Bok,* associate director, Harvard Observatory, $2,500 for an objective prism for the study of spectra of faint southern stars; *John F. Taylor,* assistant professor of biological chemistry, Washington University School of Medicine, $963 for a study of the physicochemical characterization of enzyme proteins at low temperatures.

Curt P. Richter was awarded the **Howard Crosby Warren Medal** by the Society of Experimental Psychologists at its annual meeting April 14–15 at the University of Rochester. The medal was awarded to Dr. Richter for his studies of self-regulatory functions in humans and animals.

The Howard Taylor Ricketts Medal was awarded on May 8 to S. Burt Wolbach, Harvard University professor emeritus of pathology. Dr. Wolbach, pioneer in the field of rickettsial diseases, made some of the earliest studies on the pathology of Rocky Mountain spotted fever and typhus. He is also known for his contributions to the knowledge of vitamin A and C deficiency diseases.

The National Academy of Sciences made the following awards at its annual dinner on April 25, in Washington, D. C.: the **Henry Draper Gold Medal** for 1949 was conferred on Otto Struve of the Yerkes and McDonald Observatories in recognition of his contributions to astronomical physics; the **Daniel Giraud Elliot Gold Medal** for 1946 was presented *in absentia* to Robert Broom, keeper of vertebrate paleontology and an-

thropology in the Transvaal Museum, Union of South Africa, for his part in preparing *The South African Fossil Ape-Men, the Australopithecinae,* published January 31, 1946; the 1949 **Mary Clark Thompson Gold Medal** and honorarium were given *in absentia* to Lauge Koch of Copenhagen, for exploration and geologic studies in East Greenland.

The 1950 John J. Abel prize in pharmacology has been awarded to George B. Koelle, Chalfont Fellow in Ophthalmology, Wilmer Institute, Johns Hopkins Medical School, for his research on the histochemical differentiation of types of cholinesterase and their localization in the tissues of the cat. The $1,000 prize and bronze medal have been donated to the American Society for Pharmacology and Experimental Therapeutics by the Eli Lilly Company to stimulate fundamental research in pharmacology and experimental therapeutics of young investigators working in colleges, universities, hospitals, or nonprofit institutes. Further information concerning this award can be obtained from the secretary of the society, H. B. Haag, Medical College of Virginia, Richmond.

Colleges and Universities

A new department of environmental medicine has been created at Johns Hopkins University School of Hygiene and Public Health for research combining medical investigation and hospital treatment of disease produced by environment and work in hygiene and public health on such diseases as they affect the community. Joseph L. Lilienthal, Jr., has been appointed professor of environmental medicine but will continue as head of the Physiological Division of the Department of Medicine at Johns Hopkins Hospital and as associate professor of medicine at the Hopkins School of Medicine. Anna Baetjer will serve as assistant professor in the new department.

A School of Natural Resources will be established at the **University of Michigan** this fall, under provisions of a ten-year grant of $100,000 from the Charles Lathrop Pack Forestry Foundation. The grant provides for an additional faculty member, the Pack Professor of Conservation, who will develop graduate and undergraduate programs in conservation along broader lines than those usually followed. Samuel T. Dana, dean of the present School of Forestry and Conservation which the new school will replace, will continue as dean of the new school.

A new venereal disease experimental laboratory was formally opened May 16 at Chapel Hill, North Carolina. The laboratory is the joint project of the School of Public Health, the University of North Carolina, and the U. S. Public Health Service and will be devoted to fundamental research in venereal diseases. The staff includes Harold J. Magnuson, senior surgeon of the Public Health Service, who will direct the laboratory, George O. Doak, director of the chemistry group, Henry Tauber, chief biochemist, and J. D. Thayer, chief bacteriologist. Approximately 25 scientists will do research in organic chemistry, physical chemistry, biochemistry, bacteriology, and related fields.

The University of Pittsburgh's Physics Department has established an A. G. Worthing Memorial Award of $100 to be given annually to an outstanding senior physics student. The first award was made this year to William M. MacDonald, a senior at the university.

Summer Programs

An intensive clinical course in cerebral palsy will be given at Chicago's Cook County Graduate School of Medicine July 31–August 12 by M. A. Perlstein. The course, which will include lectures, discussion, and clinic demonstrations, is designed primarily for physicians working with children. The fee is $150, of which $25 is payable on registration. Communications should be addressed to the Cook County Graduate School of Medicine, 427 South Honore Street, Chicago 12.

The Harvard Summer School will offer a program in **Science in General Education** under the direction of I. Bernard Cohen and Fletcher Watson. The program will include a workshop which opens July 10, providing opportunity for teachers and prospective teachers to examine methods, aims, and practices applied in introductory science courses at Harvard. Those enrolled may choose from three science courses — "The Development of Physical Theory from Copernicus to Einstein," "The Philosophy of Modern Science," "Human Behavior," and a special intensive course beginning July 5 and continuing to August 12. Inquiries should be directed to Harvard Summer School, 2-L Weld Hall, Cambridge 38, Massachusetts.

Industrial Laboratories

The Campbell Pharmaceutical Company of New York has appointed Robert A. Lehman as director of research. Dr. Lehman has been an instructor in pharmacology at New York University College of Medicine since 1938.

The Bendix Aviation Corporation has appointed Albert C. Hall, director of the dynamic analysis and control laboratory of Massachusetts Institute of Technology, as associate technical director of the Bendix Aviation Research Laboratories in Detroit. Dr. Hill is an authority on servomechanics, and developed a control system for guided missles used by the Navy.

Meetings and Elections

The second national medicinal chemistry symposium of the American Chemical Society's Medicinal Chemistry Division will be held at the University of Notre Dame June 15–17. All scientists interested in this field are invited to attend. The registration fee for nonchemists and chemist members of the ACS is $5; for chemists who are not ACS members, $10. Further information may be obtained from Dr. Kenneth N. Campbell, Department of Chemistry, University of Notre Dame, Notre Dame, Indiana.

The 31st annual meeting of the Pacific Division of the AAAS will be held at the University of Utah, Salt Lake City, June 19–24. The first general session will be a symposium on "The Western Migration

and Its Consequences,'' on Tuesday morning, June 20. L. M. Klauber, president of the Pacific Division, will give an address Wednesday evening, June 21.

Nineteen societies associated or affiliated with the Pacific Division will participate, and the American Society of Ichthyologists and Herpetologists is holding its national meeting in conjunction with these meetings. Further information may be obtained from I. O. Horsfall, Director of the Extension Division of the University of Utah.

The First International Microchemical Congress will be held in Graz, Austria, July 2–6, under the auspices of the Austrian Society of Microchemistry. All microchemists and analytical chemists are invited to attend. The main purpose of the meeting is to provide an exchange of experiences in the microchemical field on an international basis. In addition, an effort will be made to standardize the microchemical apparatus of all countries. Information regarding registration may be obtained from Dr. Herbert K. Alber, 6 Windsor Circle, Springfield, Pennsylvania.

Science Service, Inc., at its annual meeting in Washington, D. C. on April 27, reelected five trustees for a three-year term: R. A. Millikan, professor emeritus and vice president, board of trustees, California Institute of Technology, Pasadena; Ross G. Harrison, Sterling Professor of Biology, emeritus, Yale University; O. W. Riegel, director, Lee School of Journalism, Washington and Lee University; Kirtley F. Mather, professor of geology at Harvard University and president elect of the AAAS; and Frank R. Ford, editor, *Evansville Press*, Evansville, Indiana.

Trustees of Science Service are nominated by the AAAS, the National Academy of Sciences, the National Research Council, the E. W. Scripps Estate, and the journalistic profession.

A symposium on the physiological mechanism of lactation will be held in Strasbourg, August 22–29. American scientists who have been invited to attend are William R. Lyons, of the University of California's Medical School in Berkeley, and Warren O. Nelson, professor of medical anatomy and histology, University of Iowa College of Medicine.

The British Association for the Advancement of Science will hold its annual meeting in Birmingham, August 30–September 6. Preliminary programs and registration forms are available upon application to the secretary, David N. Lowe, British Association, Burlington House, Piecadilly, W. 1, London. Registration forms should be returned as early as possible to the secretary.

The Wisconsin Academy of Sciences, Arts, and Letters has elected the following officers for 1950: president, W. C. McKern, Milwaukee Public Museum; vice president in science, Katherine Graecen, Milwaukee-Downer College; and secretary-treasurer, Banner Bill Morgan, University of Wisconsin.

The Council of the Federation of American Scientists elected the following officers at its May 1 meeting in Washington, D. C.: chairman, W. A. Higinbotham, associate head of electronics at Brookhaven National Laboratory; vice chairman, H. C. Wolfe, professor of physics at Cooper Union, New York City; secretary-treasurer, Jules Halpern, associate professor of physics, University of Pennsylvania. New members of the executive committee are Arthur Roberts, associate professor of physics, State University of Iowa, Clifford Grobstein, National Institutes of Health, Bethesda, Maryland; and Gerhardt Friedlander, Brookhaven National Laboratory.

In signing the **National Science Foundation Act,** on May 9, President Truman described the foundation as designed ''to develop a national policy for the promotion of basic research and education in the sciences.'' ''The Foundation,'' he said, ''will be an independent agency, in the Executive Branch of the Government, headed by a National Science Board and a Director.''

Establishment of the foundation climaxes five years of effort, but its success will depend upon the leadership of judiciously selected personnel. Presidential appointments to the board and to the directorship should now be a major concern of all scientists.

Recently Received—

Science in South Africa. Council for Scientific and Industrial Research, Pretoria, South Africa. (South African Scientific Liaison Office, 1785 Massachusetts Ave., Washington 6, D. C.)

Proceedings, Biology Section, Royal Society of Edinburgh. 1949. Vol. 43, Part 3 and 4. Oliver and Boyd, Tweeddale Court, Edinburgh; 98 Great Russell St., London, W.C. 1. 24s.6d. and 12s.6d.

***Color Pattern Inheritance in Some Frogs of the Genus* Eleutherodactylus.** Coleman J. Goin. Vol. 9, No. 1, Chicago Academy of Sciences, 2001 N. Clark St., Chicago 14.

***New Species of Nearctic Pselaphid Beetles and a Revision of the Genus* Cdius.** Orlando Park. Vol. 8, No. 16. Chicago Academy of Sciences, 2001, N. Clark St., Chicago 14.

Bibliography on Offshore Petroleum Developments. Emory N. Kemler. Division of Oceanography and Meteorology, Southwest Research Institute, 312 Oil and Gas Building, Houston, Texas.

Axonometric Method of Descriptive Geometry. William Henry Roever. Edwards Brothers, Inc., Ann Arbor, Mich.

Malnutrition and Starvation in Western Netherlands, Parts I and II, September 1944–July 1945. General State Printing Office, The Hague, Netherlands.

Vitamins, Coenzymes and Nucleotides. Alexander R. Todd. Nieuwland Lectures, Vol. 3, 1948. University of Notre Dame, Notre Dame, Ind. $1.00.

Scientific Bases of an International Biological Control Organization. Unesco publ. International Union of Biological Sciences, 57 rue Cuvier, Paris Ve.

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Academic Position: Ph.D. (cellulose) 1946. Age 29. Assistant Professor Organic Chemistry. 4 years experience teaching elementary, qualitative, advanced organic, high polymer chemistry. Experience directing sterol, cellulose, textile research. Box 155, SCIENCE. X

Academic Position with opportunity for research is desired by Ph.D., age 29, with broad training including four years of industrial research experience and one year post-doctoral fellowship. Organic chemistry, pharmaceuticals, natural products. Box 157, SCIENCE. X

Bacteriologist: Ph.D. June. Biochemistry minor. Four years laboratory and teaching experience; registered M.T.; Sigma Xi. Box 167, SCIENCE. X

Bacteriologist: Ph.D. June, large midwestern University, antibiotic research. Teaching or research position desired in East. Box 169, SCIENCE. X

Bacteriologist: Ph.D.; ten years' experience in clinical bacteriology and research, one of country's leading clinics; two years, teaching assistant (bacteriology) state university; several years, chief bacteriologist (enzyme production), research laboratories, industrial company; for further information, please write Burneice Larson, Medical Bureau, Palmolive Building, Chicago. X

Biochemist: Ph.D. June 1950. Organic and bacteriology minors. Research on antibiotics. Desires industrial research or academic position with research. Location immaterial. Single, age 30, Jewish. Box 158, SCIENCE. 5/26

Biochemist: Ph.D. 1950. Desires academic position. Thesis in Steroid Chemistry. Minor: Physiology. Box 162, SCIENCE. X

Biologist: retiring shortly long successful head department in College Liberal Arts would like active academic work. Highest training, wide experience, extensive recognition, unimpaired vigor. Employing institution will not be burdened with aged man—just say good-bye. Box 163, SCIENCE. R6/2

Biologist: M.S. plus. Wide biological and chemical background. Two years assisting experience. Desires teaching position. Box 168, SCIENCE. 5/26

Geologist: Ph.D. Geological Engineering minor. Broad training. Ten years university teaching, five years economic, areal geology field work. Administrative experience. Desires academic or industrial position. Box 151, SCIENCE. 5/19

Geologist: Petrologist-Mineralogist, Ph.D. this year. 27. College teaching experience. Desires college teaching or industrial research position. Box 156, SCIENCE. X

Microbiologist-Bacteriologist: Ph.D. interested in academic position at professor level, for teaching, pure and applied research. Extensive academic experience and industrial research on antibiotics. Box 159, SCIENCE. 5/26

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Ph.D. Cytology with medical science training desires position teaching histology and opportunity for research. Box 160, SCIENCE. X

Physicist: Available Sept. 1950. Man, single, M.S. plus additional study. Over twenty years teaching in American colleges and universities. Experienced in organization of new courses and compilation of laboratory manuals. Box 152, SCIENCE. 5/19

Physiologist: M.S. Woman. Background in Organic and Biochemistry. Research and college teaching experience. Desires part-time pharmaceutical or research position in New York City. Box 150, SCIENCE. 5/19

Plant Breeder, crop production: Ph.D. Desire academic or seed company position. Research experience in field crops. Box 165, SCIENCE. X

Technical information specialist: Graduate organic chemists, experienced in abstracting, report writing, compiling bibliographies, locating technical information. Laboratory experience in plastics, pharmaceuticals. Read German, French. Prefer West Coast. Box 117, SCIENCE. 5/5, 5/19

Zoologist: Instructor; young woman with M.A. Teaching experience in Anatomy, Animal Histology and General Biology. Box 164, SCIENCE. X

Zoologist: M.S., desires college position for fall and/or summer. Experienced. Female. 24. Box 166, SCIENCE. X

Zoologist: M.S. 1949. Desires doctorate opportunities with teaching or research. Available Summer or Fall. Box 149, SCIENCE. 5/19

POSITIONS OPEN

Hospital Biochemist—Ph.D. or M.S. preferred to establish and supervise biochemistry laboratory in 400-bed hospital. Apply J. M. Dunlop, Administrator, Bridgeport Hospital, Bridgeport, Connecticut. X

M.S. or Equivalent in Bacteriology or Microbiology for Bacteriology Laboratory of Eastern pharmaceutical manufacturer. Must have strong organic and biochemistry background. Duties will involve determination of anti-bacterial activity in antibiotic and synthetic substances; also microbiological assays. Give complete educational, professional and personal data to Box 154, SCIENCE. 5/19

Positions Open:
(a) **Plant pathologist,** Ph.D., plant physiologist, **Ph.D.,** enzyme chemist, Ph.D., soil chemist, Ph.D. and three biochemists (Masters' degrees required) trained in plant biology; research department, famed group and hospital, Pacific Coast. (b) **Research associate,** division of experimental medicine, university college of medicine; preferably physician interested in clinical and experimental work in cardiovascular disease; East. (c) **Ph.D. in biochemistry,** preferably with some of major work in nutrition; duties consist of conducting research on nutritional values of finished products and raw materials used in their manufacture; research department, food industry. (d) **Chemist;** research laboratories, manufacturing company; New England. (e) **Medical director;** pharmaceutical company; duties consist of developing new products, clinical investigation; Midwestern city. (f) **Electroencephalographer;** epilepsy department, large hospital; East. S5-3 Burneice Larson, Medical Bureau, Palmolive Building, Chicago. X

The Market Place

CHARGES and REQUIREMENTS for "MARKET PLACE" Ads

1. **Rate:** 20¢ per word for ***classified*** ads, minimum charge $5.00 for each insertion. Such ads are set in uniform style, without display; the first word, only, in bold face type. For ***display*** ads, using type larger or of a different style than the uniform classified settings, and entirely enclosed with separate rules, rates are as follows:

Single insertion	$16.00 per inch
7 times in 1 year	14.50 per inch
13 times in 1 year	13.00 per inch
26 times in 1 year	11.50 per inch
52 times in 1 year	10.00 per inch

2. **Payment:** For all ***classified*** ads, payment in advance is required, before insertion can be made. Such advance remittances should be made payable to SCIENCE, and forwarded with advertising "copy" instructions. For ***display*** advertisers, monthly invoices will be sent on a charge account basis—providing satisfactory credit is established.

3. **Closing Date:** Classified advertisements must be received by SCIENCE, 1515 Massachusetts Avenue, N.W., Washington 5, D. C., together with advance remittance, positively not later than 14 days preceding date of publication (Friday of every week).

For proof service on display ads complete "copy" instructions must reach the publication offices of SCIENCE, 1515 Massachusetts Avenue, N.W., Washington 5, D. C., not later than 4 weeks preceding date of publication.

BOOKS

The SHRUNKEN MOON
By J. E. SPURR
207 pages • 36 text figures • Price $4.00
BUSINESS PRESS • Lancaster, Penna.

WANTED TO PURCHASE:
SCIENTIFIC PERIODICALS
Sets and runs, foreign and domestic
SCIENTIFIC BOOKS
Entire libraries and smaller collections
WALTER J. JOHNSON
125 East 23rd Street, New York 10, N. Y.

WANTED— — YOUR PERIODICALS —
We need Complete Sets, Runs, Volumes and Single numbers.
CASH IN on your periodical accumulations NOW!
COLLEGE LIBRARY SERVICE • Dept. A, Box 311, N. Y. 3
Also send us your list of wants

Send us your Lists of **SCIENTIFIC BOOKS AND PERIODICALS** which you have for sale. Complete libraries; sets and runs; and single titles are wanted. Also please send us your want lists.
STECHERT-HAFNER, INC., 31 East 10th Street, New York 3. tf

WANTED—a copy of T. Wingate Todd's "Atlas of Skeletal Maturation (Hand)," C. V. Mosby Co., 1937. Box 161, SCIENCE. X

Your sets and files of scientific journals
are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. J. S. CANNER AND COMPANY, 909 Boyston Street, Boston 15, Massachusetts. tf

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PROFESSIONAL SERVICES

Since 1885
ALBERT TEACHERS AGENCY and COLLEGE BUREAU
25 E. Jackson Blvd., Chicago 4, Ill.
MEMBER NATA
Reliable and Discriminating Service to Colleges and Universities of the Nation and their Personnel.

AMERICAN COLLEGE BUREAU
28 E. Jackson Blvd. Chicago 4, Ill.
Universities and Colleges throughout the United States continue their great demand for recommendations for those trained in the different fields of Science. The positions range from instructorships to heads of departments.
•
Our service is nation-wide.

SUPPLIES AND EQUIPMENT

NEW 1950 CATALOG
ON
LABORATORY ANIMAL CAGES & ACCESSORY EQUIPMENT
NOW BEING PRINTED FOR JUNE MAILING—COPY SENT ON REQUEST
HOELTGE BROS., Inc.
1919 Gest St. Cincinnati 4, Ohio

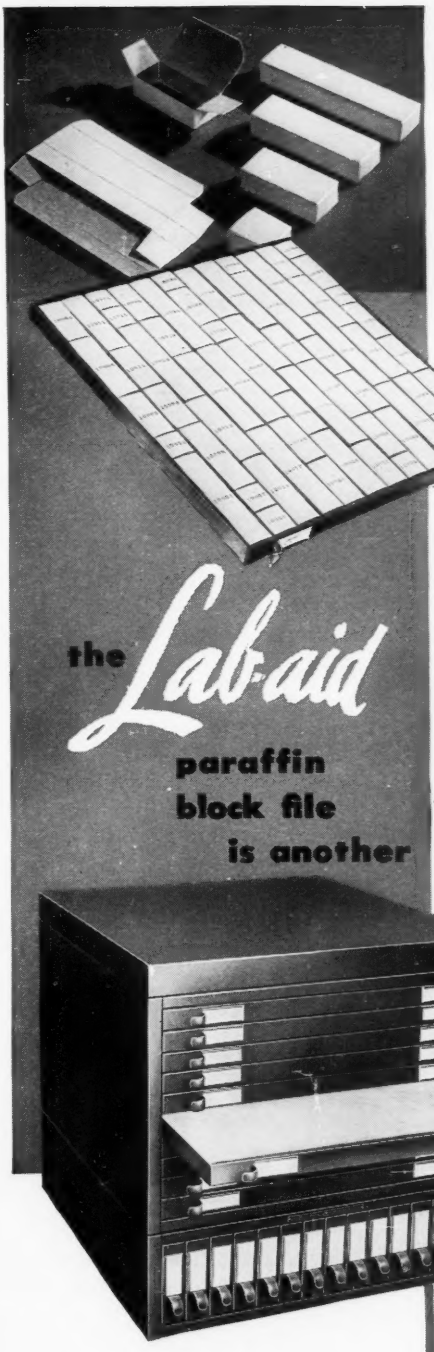
LABORATORY ANIMALS
● Clean healthy well-fed animals
● Guaranteed suitable for your needs.
Reasonably priced—Dependable service
DOGS RATS RABBITS
CATS PIGEONS HAMSTERS
MICE POULTRY GUINEA PIGS
JOHN C. LANDIS • Hagerstown, Md.

TRANSPARENT BOXES
Five Sizes: Maximum protection and visibility for samples, specimens, small parts and other objects easily lost.
Write for leaflet TR-S.
R. P. CARGILLE
116 Liberty St., New York 6, N. Y.

EAR CHAMBERS, rabbit according to Ebert. Long-working-distance Cooke fluorite objectives. Singer micromanipulators. Quartz UV monochromats. LOVINS ENGINEERING COMPANY, Scrimgeour Building, Silver Spring, Maryland. X

GLYCOCYAMINE—Hydroxyproline, L-Methionine
• AMINO ACIDS • BIOCHEMICALS
• PRE-MIXED MICROBIOLOGICAL ASSAY MEDIA
H. M. CHEMICAL COMPANY, LTD.
144 North Hayworth Avenue Los Angeles 36, California

(The Market Place is continued on next page)



The "Lab-aid" paraffin block filing cabinet is finished to match all other types of "Lab-aid" files, and stacks interchangeably with any of them. Here it is stacked upon a vertical microslide file with 1" drawers.

you needn't put up with "shoebox" block filing

Ask for a six-month-old paraffin block in many an otherwise well-ordered laboratory, and the hunt's on. Likely as not it means hours of prowling through a weird behind-the-scenes jumble of dusty, dog-eared cartons . . . trying everyone's temper, taking everyone's time, piling up hidden costs.

That's all out now, with this new "Lab-aid" block filing cabinet. You file your paraffin blocks in small, shipshape, white cardboard boxes, which come in varied sizes to accommodate all sorts of blocks, however irregular or out-sized. The boxes knock down, but spring to shape in a moment, so they're no storage problem. They're so proportioned that they fit snugly, row on row, in the shallow steel drawers.

The all-steel cabinet holds ten drawers, equipped with combination drawer-pulls and label-holders at each end. Each drawer will accommodate a gross of the 1½" boxes: other sizes in ratio (see the filled drawers above). Multiply that by ten and you've some idea of the large capacity of this compact section (it's only 19" square by 12" high). That's because there's no waste space . . . *every cubic inch is a filing inch.*

technicon laboratory essential

The "Lab-aid" laboratory filing system comprises a range of versatile equipment which brings new standards of filing efficiency to the pathological laboratory. For a descriptive bulletin, please use the coupon below.

The TECHNICON Company
215 E. 149th St., New York 51, N. Y.

☐ *Send me particulars of the new "Lab-aid" paraffin-block file.*

☐ *Send me complete "Lab-aid" filing system bulletin.*

Name.....

Address.....

City.....State.....